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Vol. 38, No. 6 *Price 10/-* *June 1959*

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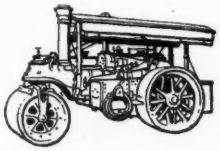

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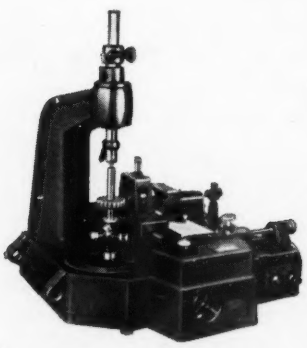

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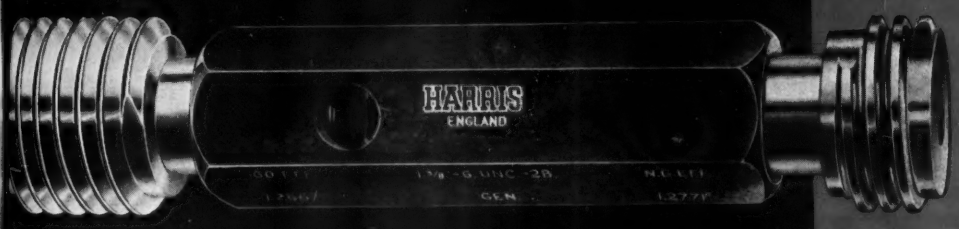

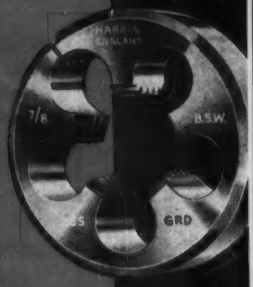

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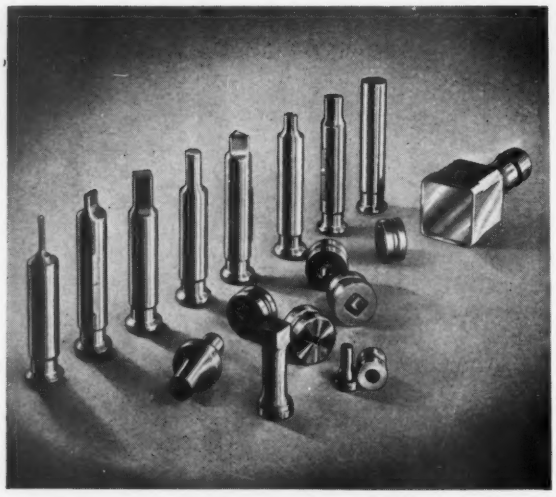

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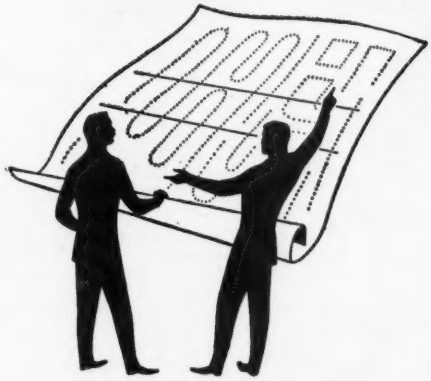

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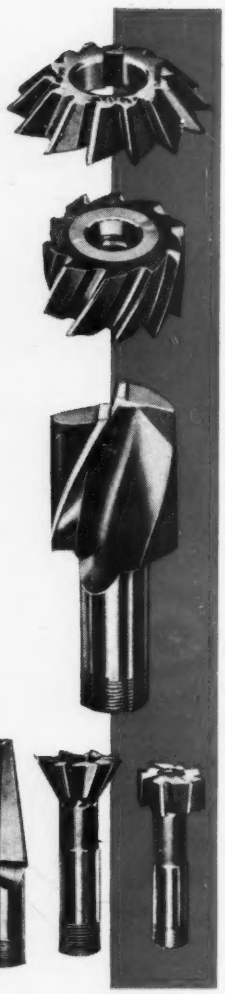

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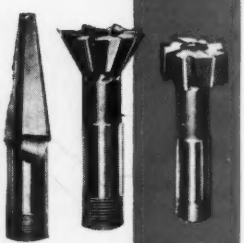

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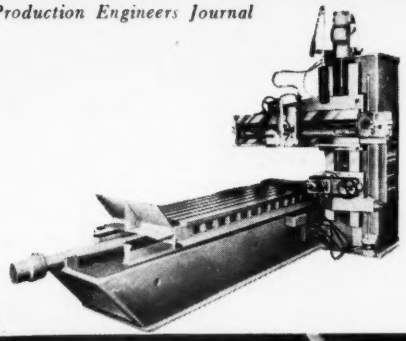

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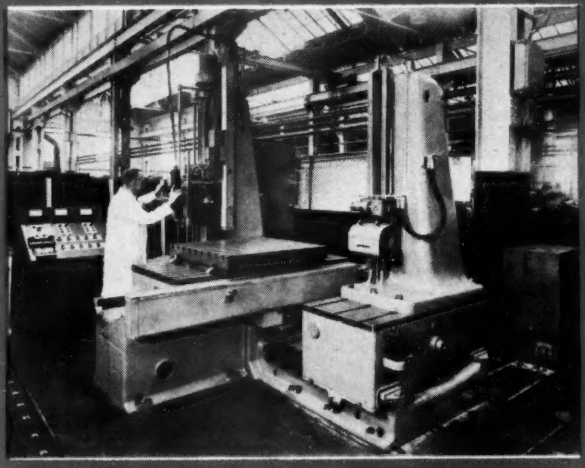

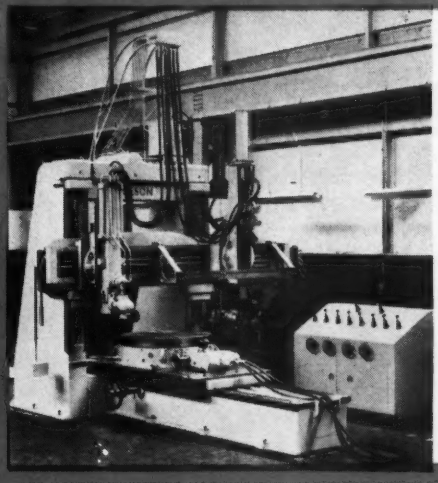

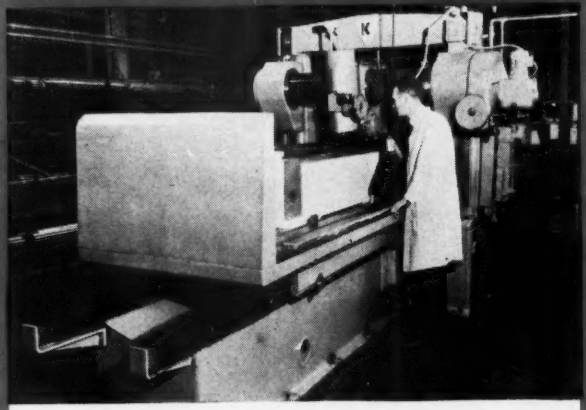

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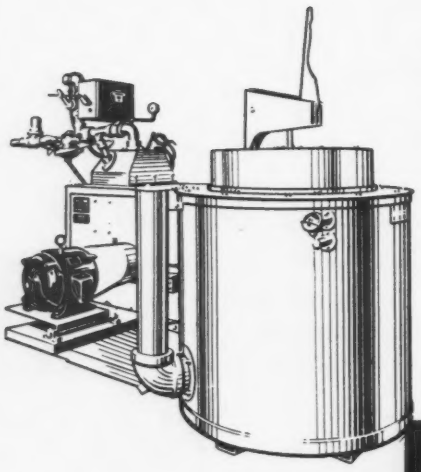
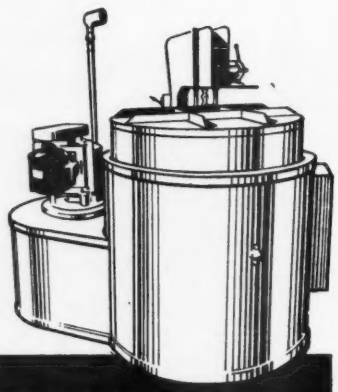


***(left)* Batch type Cyclone Tempering Furnace**

for production tempering of dense loads. Gas fired or electric. Work chamber sizes from 12″ dia. x 16″ deep to 72″ dia. x 84″ deep.

***(right)* Batch type super Cyclone Furnace**

for production tempering, hardening or normalizing. Electric (also gas or oil fired). Work chamber sizes 25″ dia. x 20″ deep to 72″ dia. x 84″ deep.



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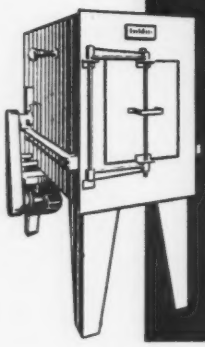

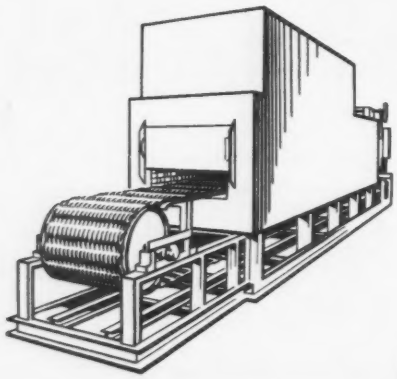

Conveyer Cyclone Tempering Furnace

for production tempering of small parts such as bolts or springs. Gas fired or electric. Temperature range up to 700°C Work chamber sizes 18″ wide x 96″ deep x 12″ high to 32″ wide x 21′ 0″ deep x 16″ high.

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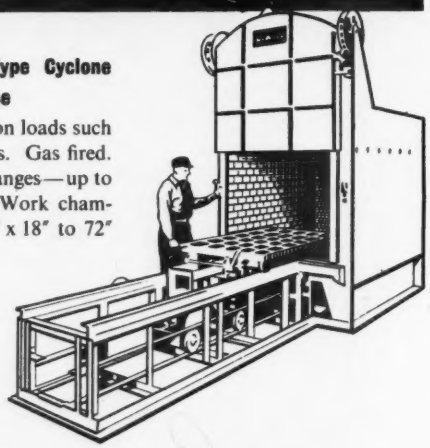

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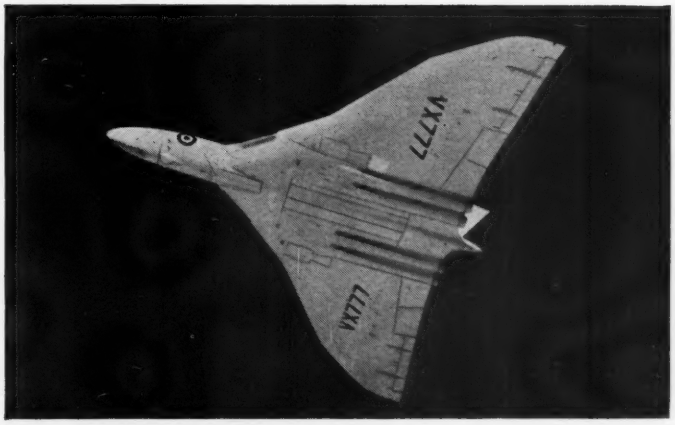

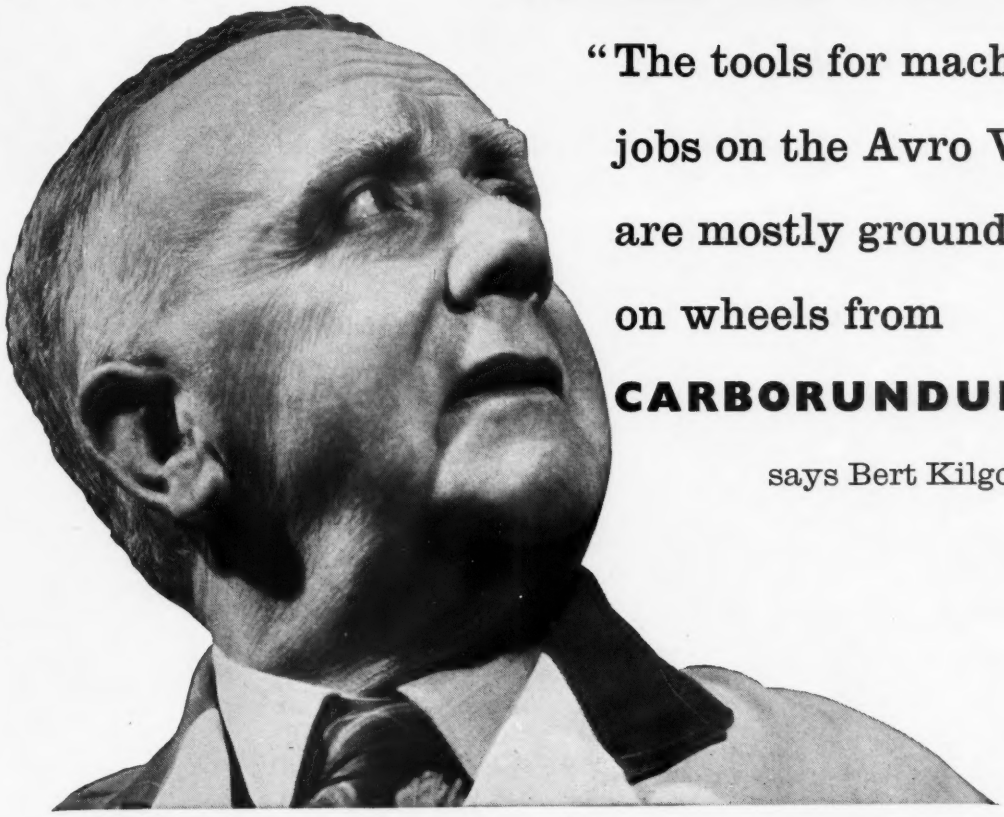

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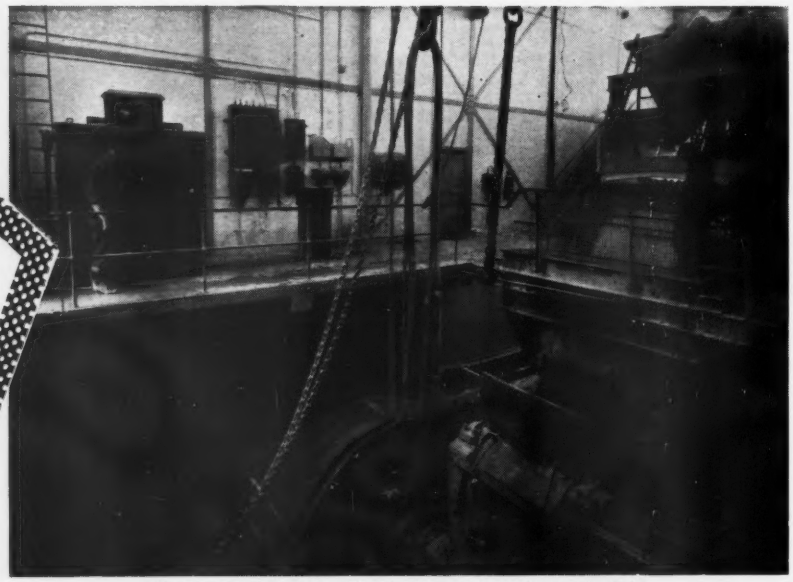

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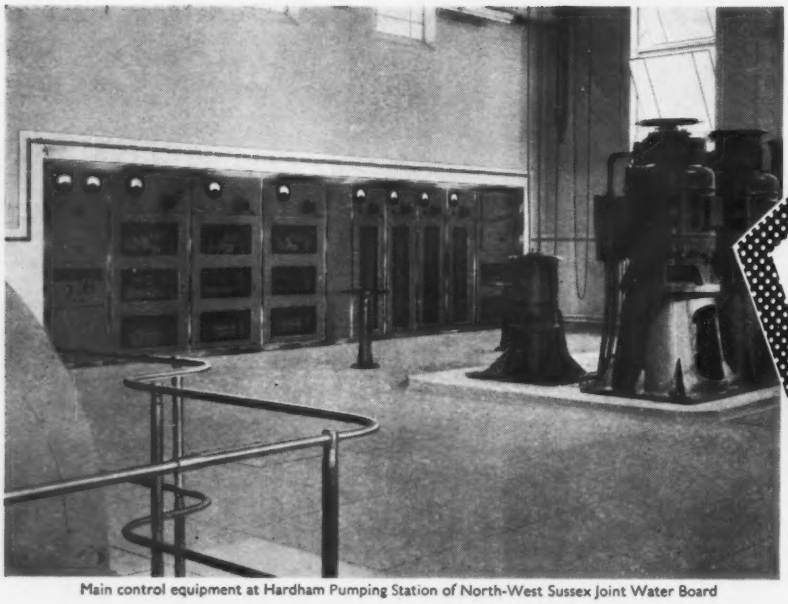

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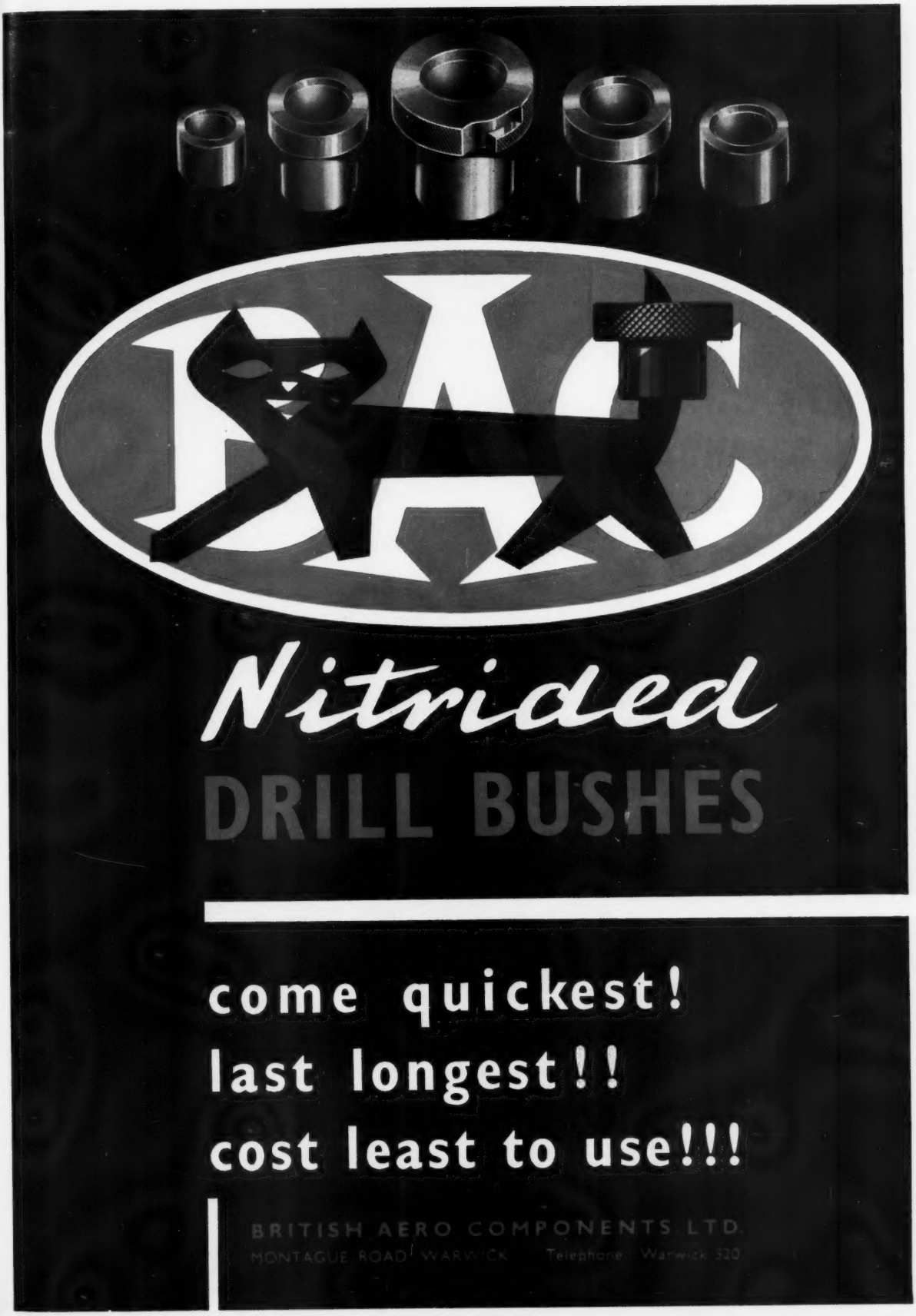
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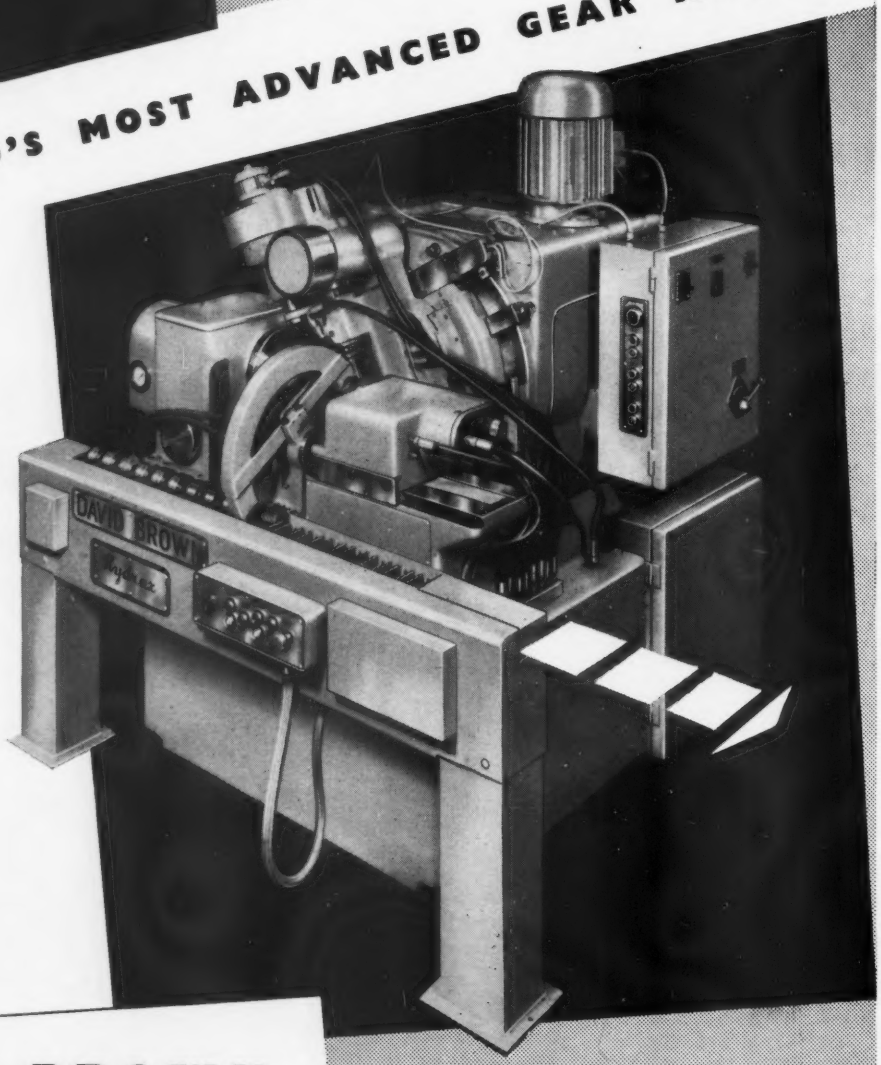

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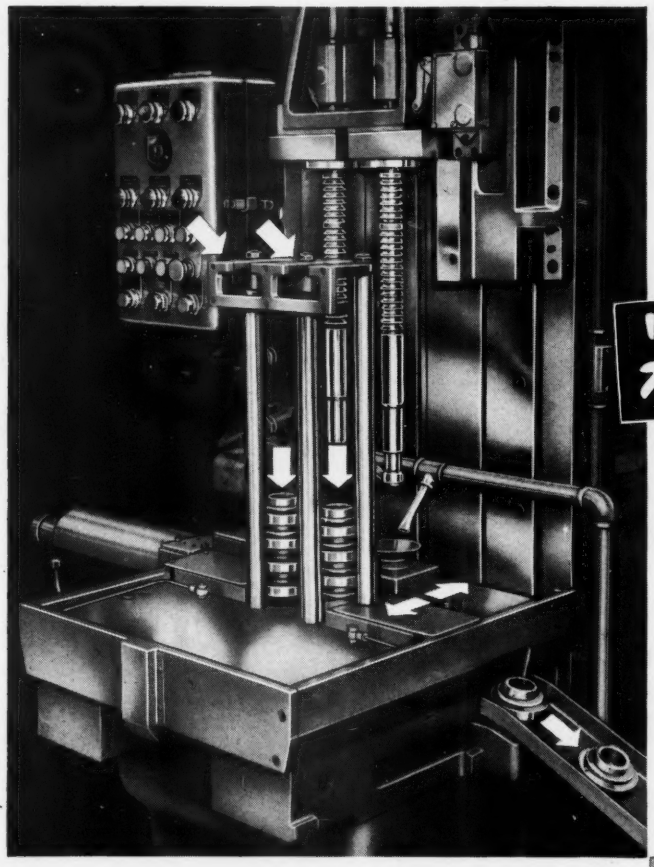

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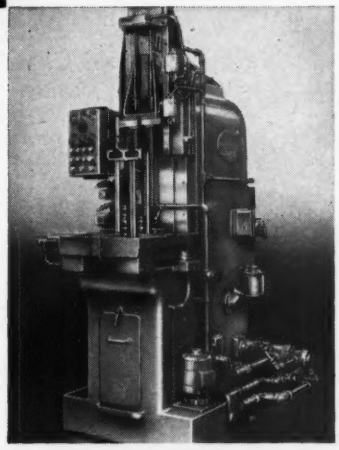

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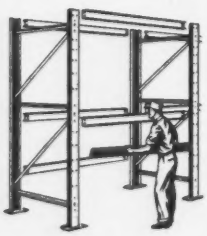

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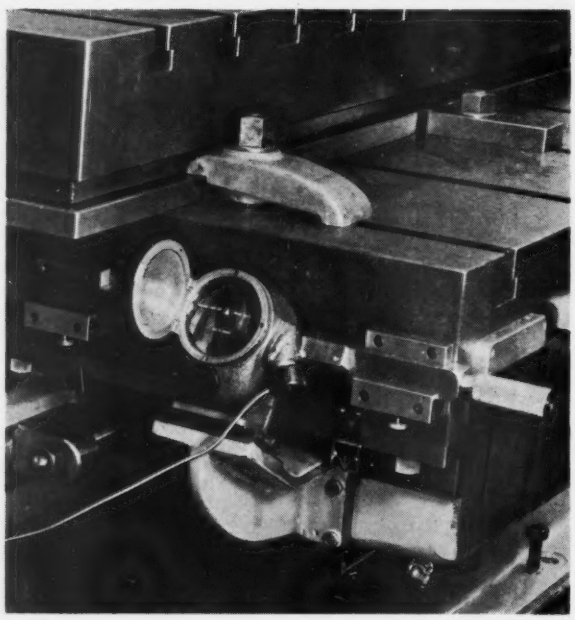

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With the Microptic Scale Reader, machine tools, measuring instruments, etc., can be set and controlled accurately, simply, and without fatigue or eye-strain.

Precision : Reads direct to 0.001 in. (metric version, 0.01 mm).

Legibility : The scale is brilliantly illuminated, and can be read easily from as far away as 6 ft. or more. The reader has a magnifying window.

Accuracy : Maximum error, 0.0006 in. in any 12 in., 0.001 in. in any 48 in. Errors are random and not cumulative.

Scale length : 6 ft. and 3 ft. lengths are standard, other lengths can be supplied.

The scale reader is small and easy to fit to the majority of machine tools, etc. It has many refinements, all described in our catalogue CT 141/c25.

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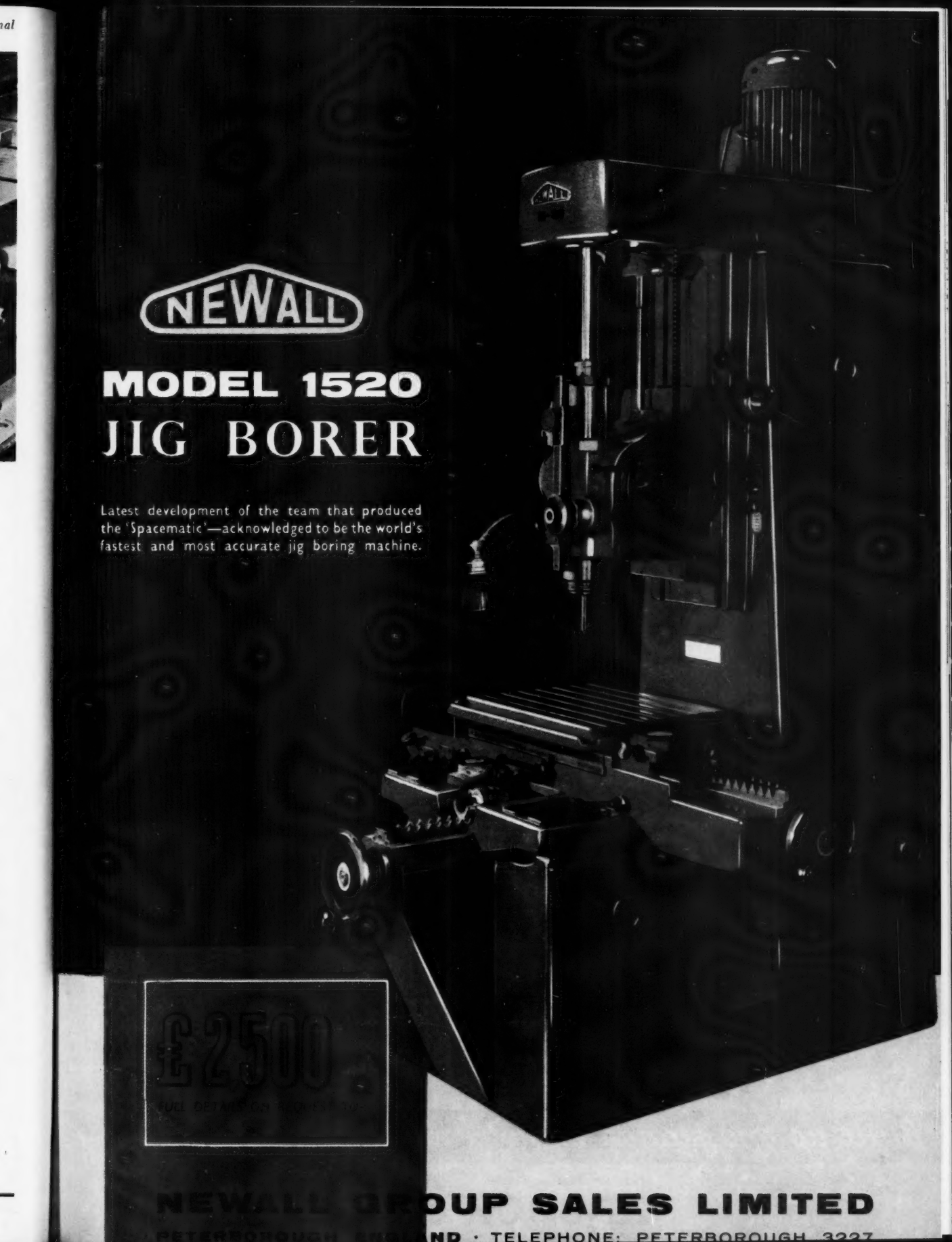
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MODEL 1520
JIG BORER
Latest development of the team that produced the 'Spacematic'—acknowledged to be the world's fastest and most accurate jig boring machine.
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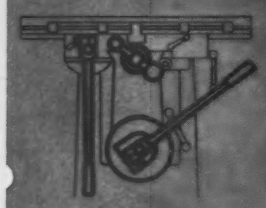
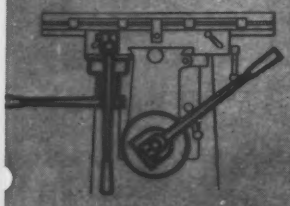
6 × 4 = 24

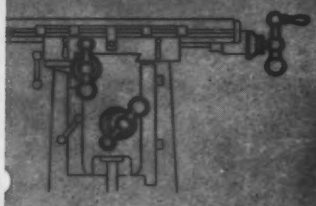
TYPES OF FEED | SPEED RANGES | POSSIBLE COMBINATIONS



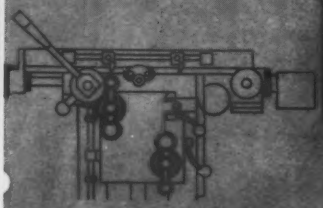
d Feed—lever, screw, lever.



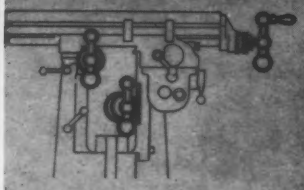
nd Feed—lever, lever, lever.



d Feed—Screw, screw, screw.



uform—semi-automatic cycle.

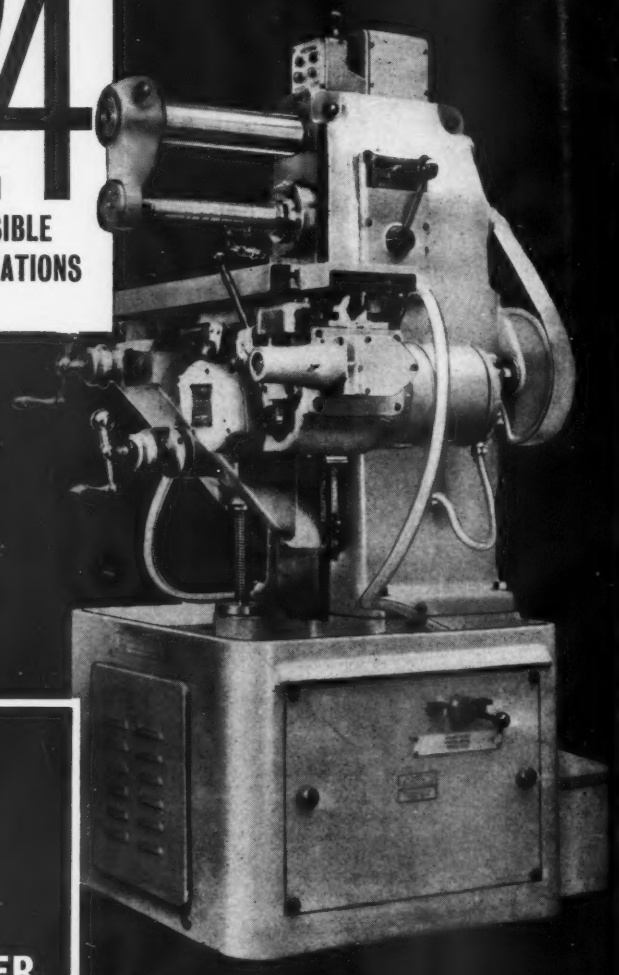


Normal automatic feed.

that's the beauty of the

A&S

MODEL 'I' HORIZONTAL MILLER



6 With automatic cycle.

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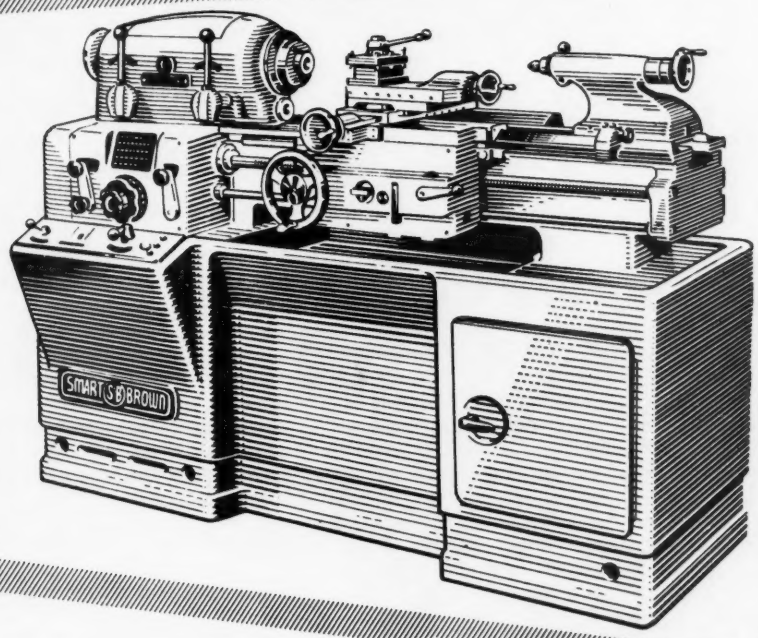

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S.S./S.C. TOOLROOM LATHE

Distance between centres: 24". 1" Collet capacity
12 Spindle speeds available: 30 to 2500 r.p.m.
Threads: 4—112 t.p.i.

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MAKERS OF PULTRA MICRO LATHES AND GRINDING MACHINES
Subsidiary of GAS PURIFICATION AND CHEMICAL COMPANY LIMITED

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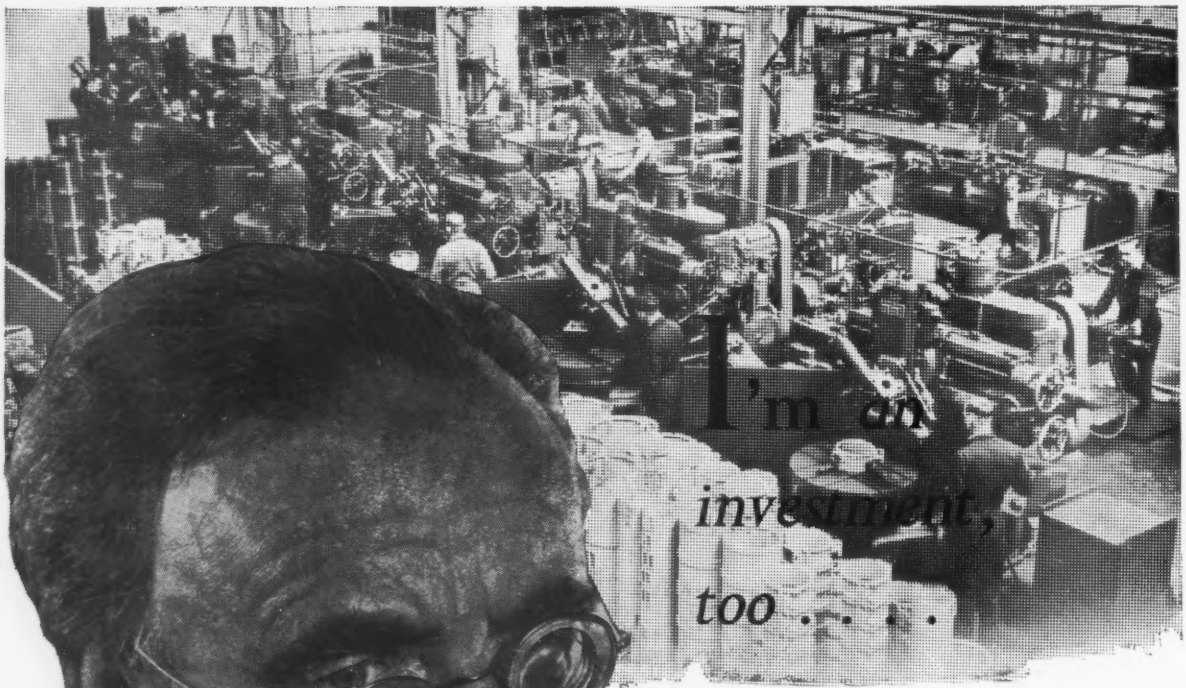

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That goes for us piece-workers too. Give us the chance to earn more by producing more, and we pay dividends.

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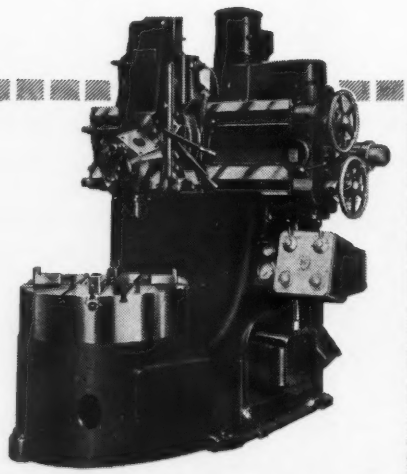

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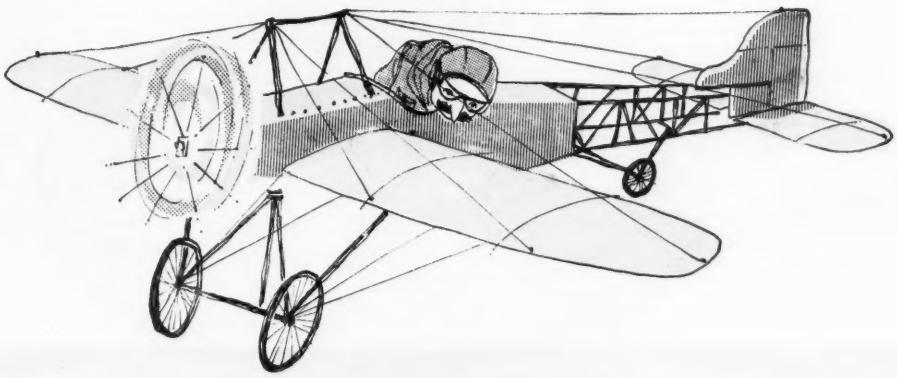

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DIAL TYPE MILLING MACHINES

Robust construction—square gibbed column ways—'Dynapoise' vibration dampening overarm—quick-change ARBOR-LOC spindle nose—automatic backlash eliminator to table are standard equipment on Model 'LL' Dial Types.
With wide speeds and feed ranges, up to 40 H.P. drive to the spindle, a great variety of attachments and automatic table cycles (Plain and Vertical machines only at extra cost), these machines fit equally well in the toolroom or production lines.

For fully detailed information write for Catalogue No. M-1915 E to—Chas. Churchill & Co. Ltd., London, Birmingham, Manchester, Gateshead. Glasgow.

CINCINNATI MILLING MACHINES LIMITED, Birmingham 24

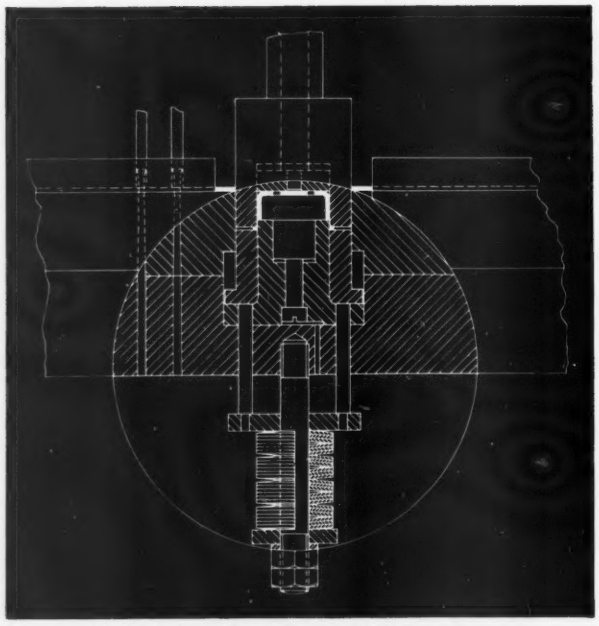
C5/59

Mass Production Units

TERRYS BELLEVILLE WASHERS— "outstanding success" in 10-ton power press

In this heavy-duty press, which raised and closed with a continuous vibratory feed at 50 per minute, Pressure Springs were required for press work dies. Normal helical compression springs were failing in from 3 to 4 days. After investigation, it was found that in this particular application, the normal compression spring was totally unsuitable for the duty it had to perform.

Terrys designed a special series-parallel stack of Belleville washers which took the place of the compression springs. These dies have now been in operation for nine months without failure and are still functioning successfully. Estimates show that these dies have now produced *over five million parts.*



Diagrammatic illustration of the use of Belleville Washers

TERRYS CIRCLIPS

¼" to ⅝" diameter. May we send you samples of circlips and a deflection chart for Belleville Washers, now used extensively in press tool work.

TERRYS

Φ131

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SPEED PRODUCTION WITH

ARO-BROOMWADE

Pneumatic Tools

LIGHT · POWERFUL
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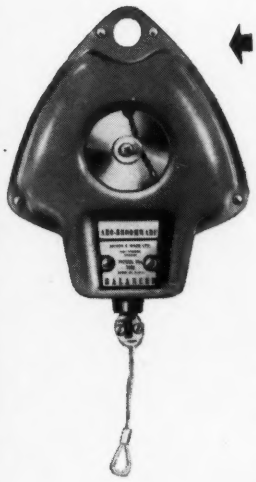
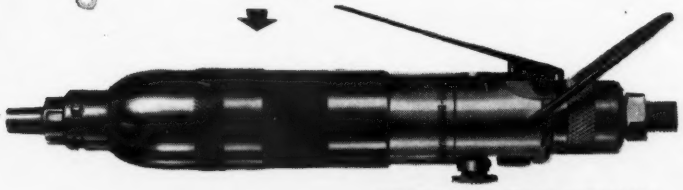


ARO-BROOMWADE spring balancers save wear on air hose or cable . . . hold tools at just the right height . . . reduce waste motion and operator fatigue to a minimum. 5 lb. and 10 lb. capacity.

ARO-BROOMWADE drill with lever-type control. Weighs less than 1½ lb. Capacity $\frac{3}{16}$" - $\frac{1}{4}$".

ARO-BROOMWADE drill with pistol grip. Weighs less than 1½ lb. Capacity $\frac{3}{16}$" - $\frac{1}{4}$".

ARO-BROOMWADE screwdriver/nutrunner is quickly converted to either role. Adjustable clutch. Reversible. Silent in operation. Weighs only 1¼ lb.



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627 SAS

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SURFACE SNOW GRINDERS

SNOW

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Araldite *epoxy resins*

Araldite is a registered trade name

Araldite epoxy resins are used

- for casting high grade solid insulation
- for impregnating, potting and sealing electrical windings and components
- for producing glass fibre laminates
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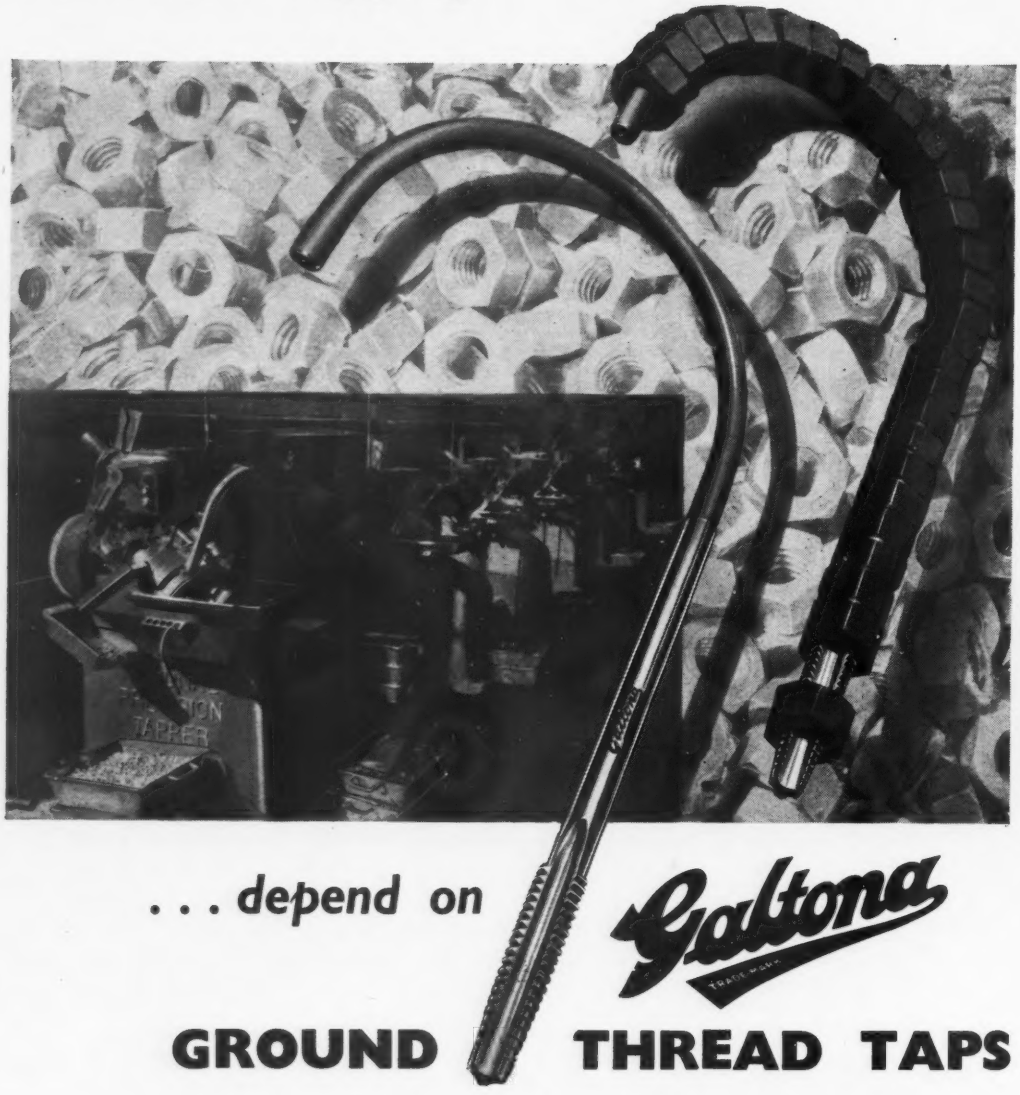
A.P. 464

for continuous tapping



. . . depend on Galtona

GROUND THREAD TAPS

On this battery of machines GALTONA Ground Thread Bent Shank Nut Taps are used for the fast continuous production of nuts. The taps illustrated are of the " National Hook " type, but all patterns of nut taps can be supplied in various types of bends and in straight shank. Wherever taps have to produce accurate threads for long periods under arduous conditions, the natural choice is GALTONA.

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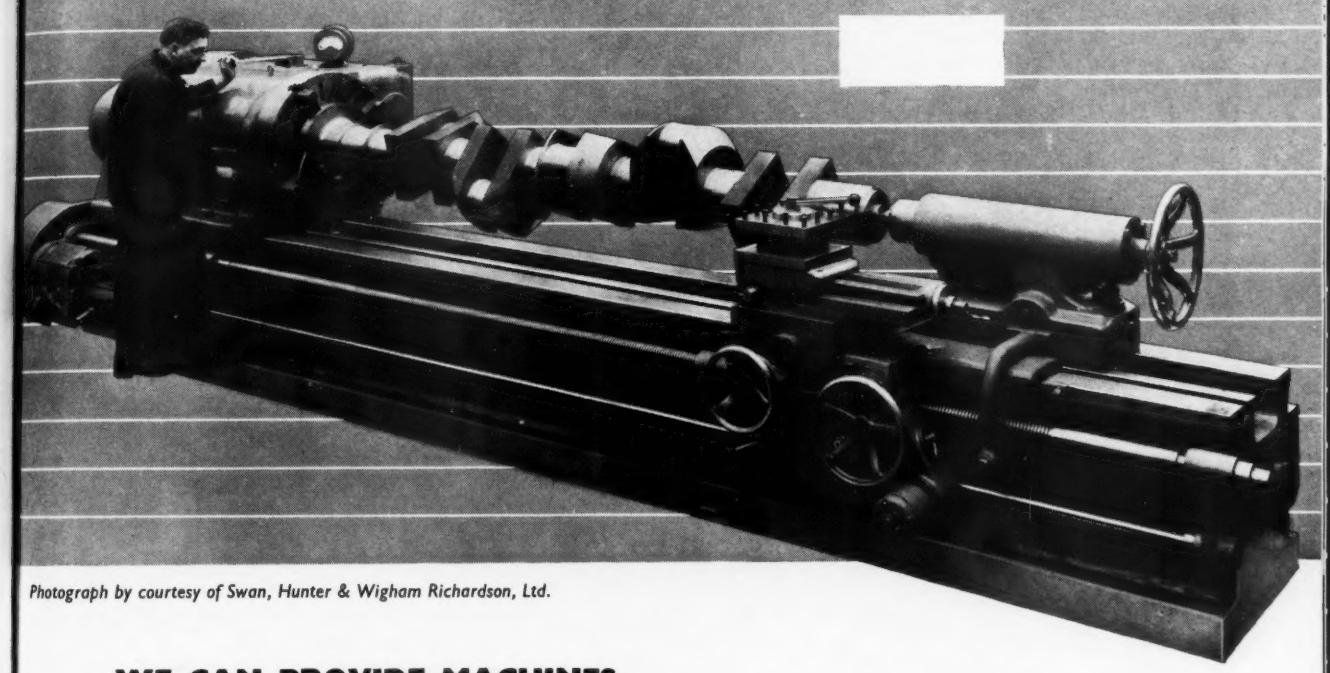
BETWIXT OR BETWEEN ?



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WE CAN PROVIDE MACHINES
WITH ANY REASONABLE LENGTH OF BED AND
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YOU CAN TURN COMPONENTS
SWINGING UP TO 42 in. OVER THE BED
33 in. OVER THE SADDLE, USING UP TO 50 H.P.

DENHAM LATHES

Centre lathes from 17 in. (430 mm) to 42 in. (1065 mm) swing
Surfacing and boring lathes of 17 in. (430 mm) and 25 in. (635 mm) swing

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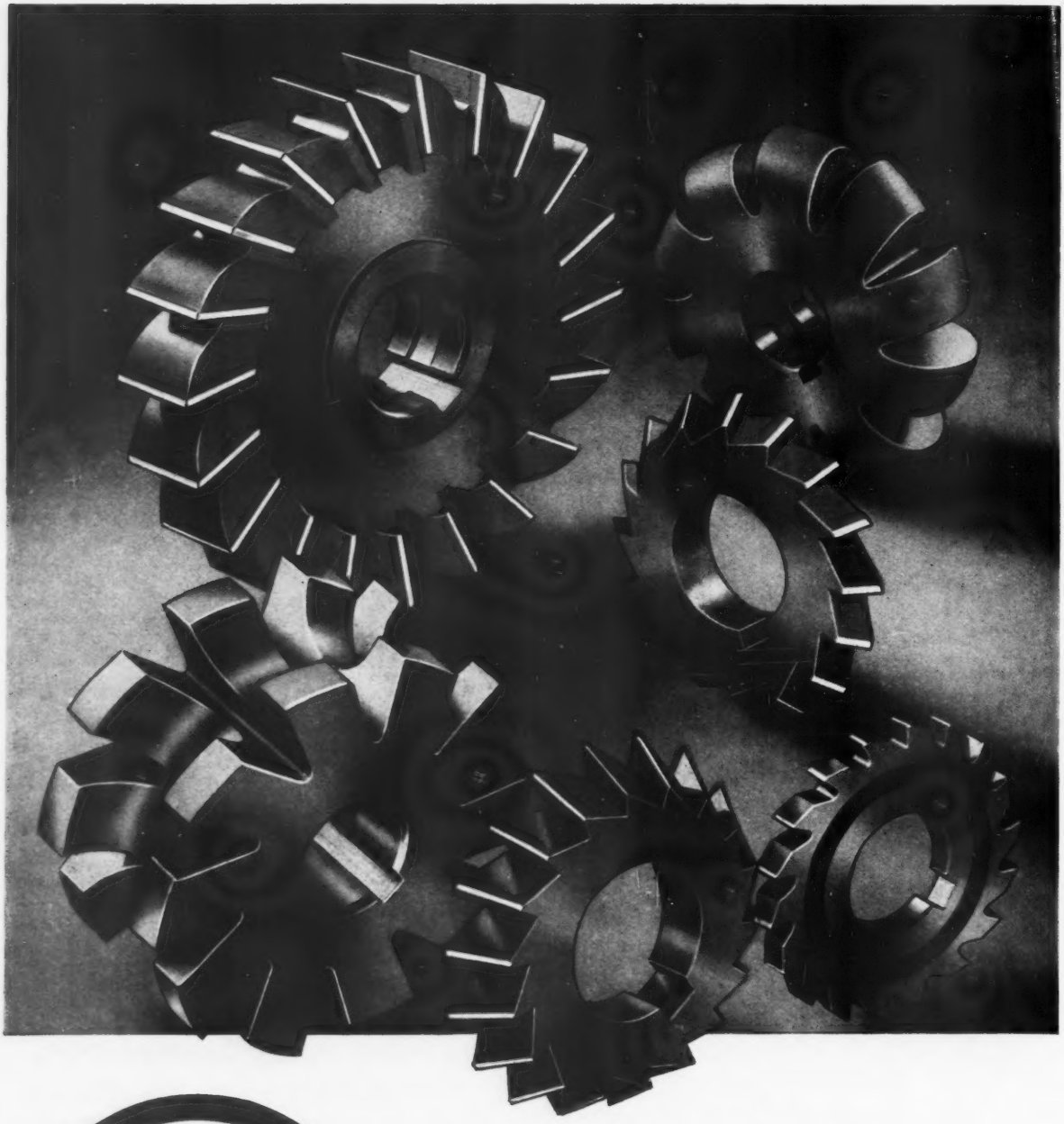

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Standard Milling Cutters

and furnishing the right cutter at the right time. Write for our Stock Card showing the full range of sizes guaranteed as being available by return.

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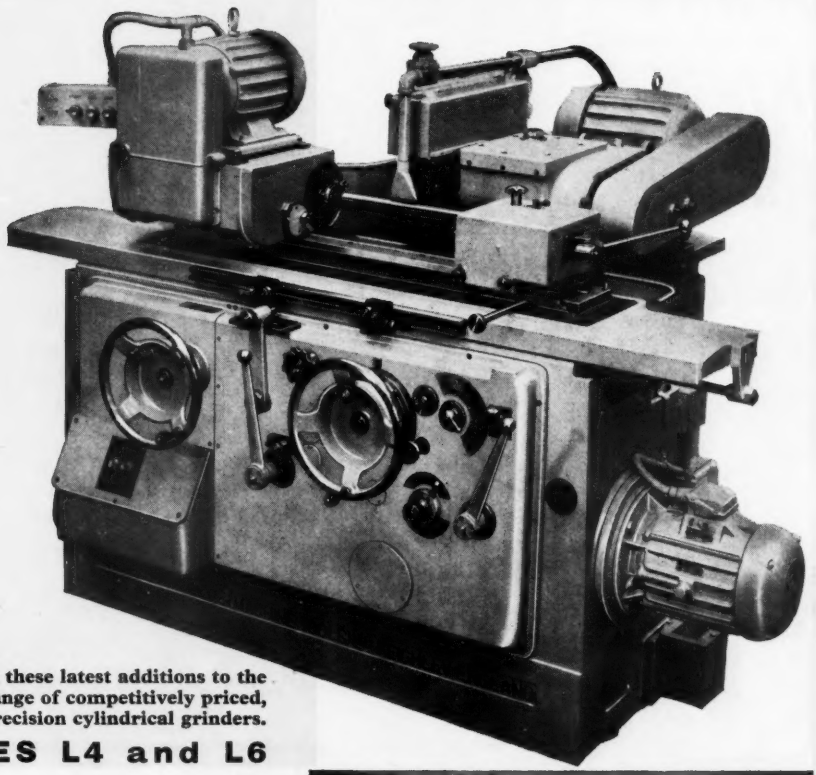
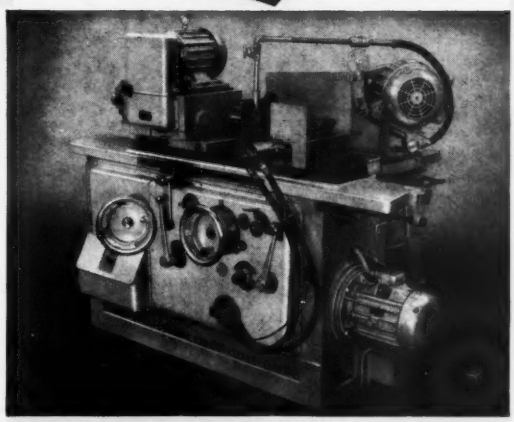


With these latest additions to the Newall-Keighley range of competitively priced, high precision cylindrical grinders.

SERIES L4 and L6

Features:

- Capacity between centres—18 inches (18 or 24 inches in type L6), maximum grinding diameter—6 inches.
- Compactness—self-contained unit reduces space requirements to a minimum.
- Fully hydraulic operation of wheelhead and table movement.
- Unit construction of hydraulic control panel simplifies operation and aids servicing.
- Built to give toolroom tolerances and superior component finish under exacting production conditions.
- Hydraulic wheelhead—mounted dresser or internal grinding head included in wide range of optional equipment.



SERIES L6
Angle Head Grinder

This high production machine with 45° angle head for grinding an external diameter and adjacent face of a component from one setting has an extensive field of application in modern engineering practice. Built to the same sturdy proportions as the plain grinder illustrated above and with similar features, it is offered with a capacity of 18 inches or 24 inches between centres and will grind components up to 6 inches diameter.

NEWALL-KEIGHLEY

For further details or machine demonstration apply to:

NEWALL GROUP SALES LIMITED

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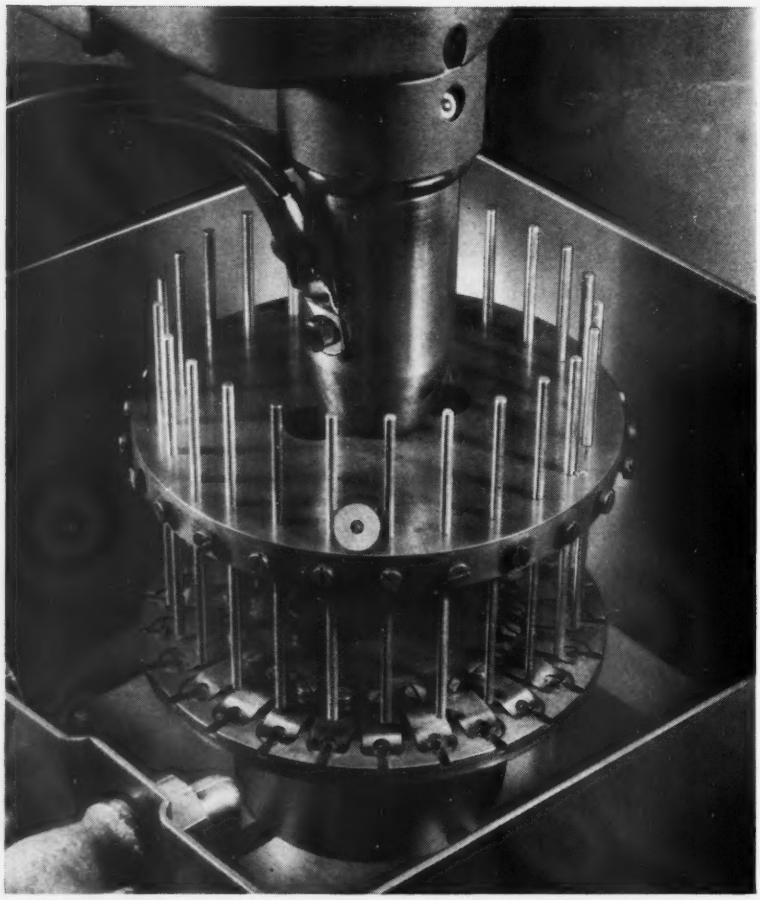
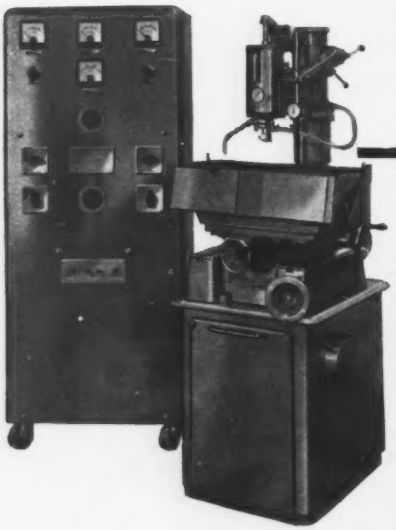
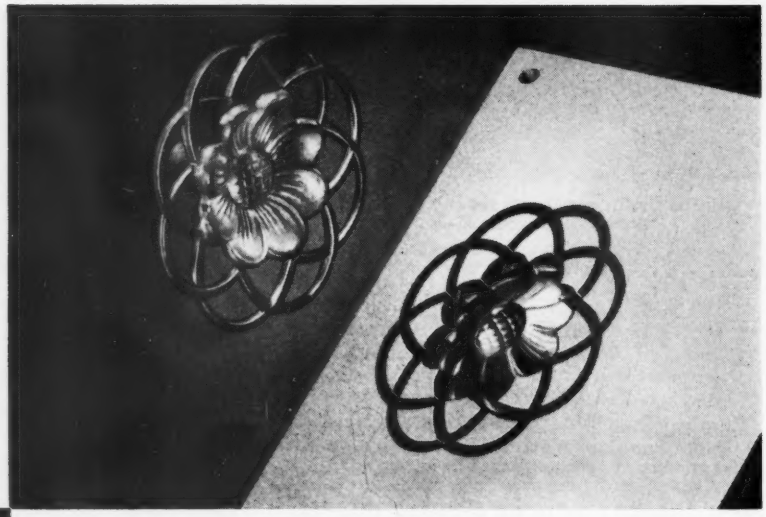
P.2805

SPARK MACHINED from the SOLID



(*Right*)
Holder used in conjunction with a jig for the precise boring of small carbide components.





(*Right*)
An intricate electrode (Mazak) and finished workpiece (high carbon steel).

The latest **IDP** **SPARCATRON**

IMPREGNATED DIAMOND PRODUCTS LTD · OF GLOUCESTER · ENGLAND

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LAPOINTE

British built broaching machines

This photograph illustrates the HP.30 Hydraulic Machine broaching components with a spline broach. The machine is controlled by push buttons placed conveniently at the operator's right hand. Other features include automatic limit switches and variable cutting speeds.

Standard Horizontal Machines range from 5000 lb pull—30" stroke to 100,000 lb pull—78" stroke

Photographs: Courtesy of The Butler Machine Tool Co Ltd Halifax

come to LAPOINTE for better broaching

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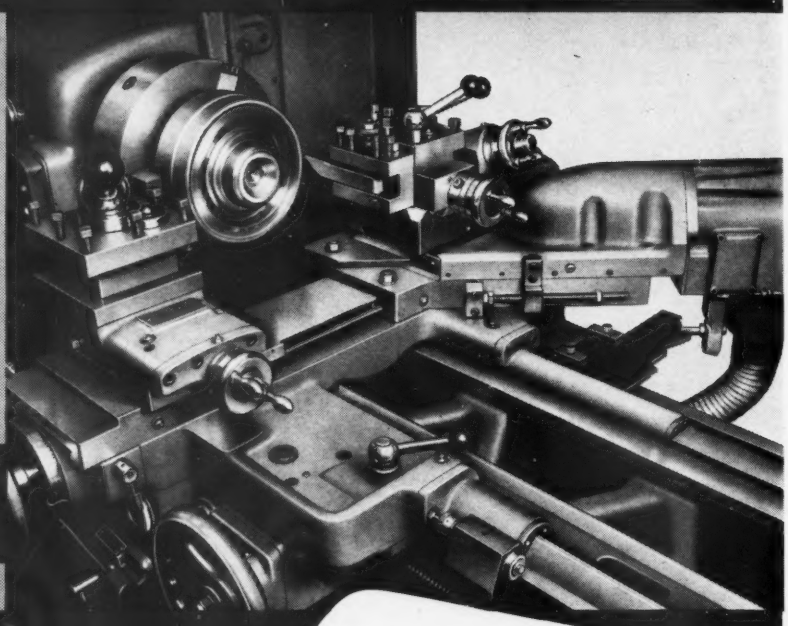
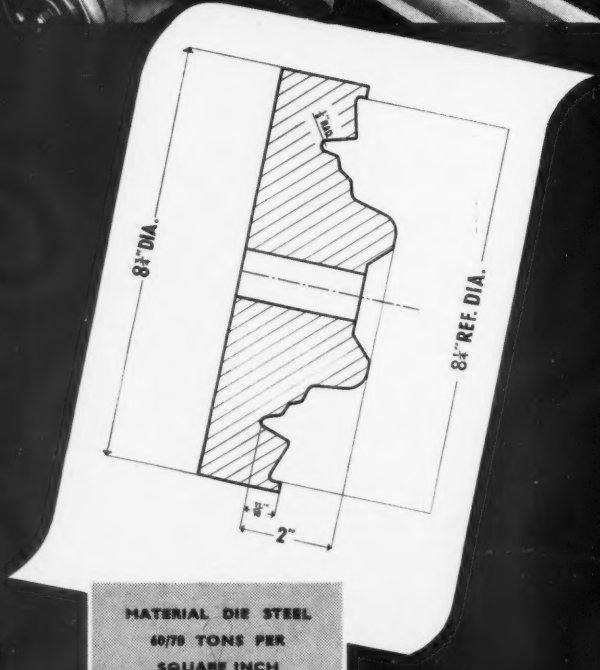
CUT production time and costs!

face copying on a D.S.G. lathe with hydraulic copying unit

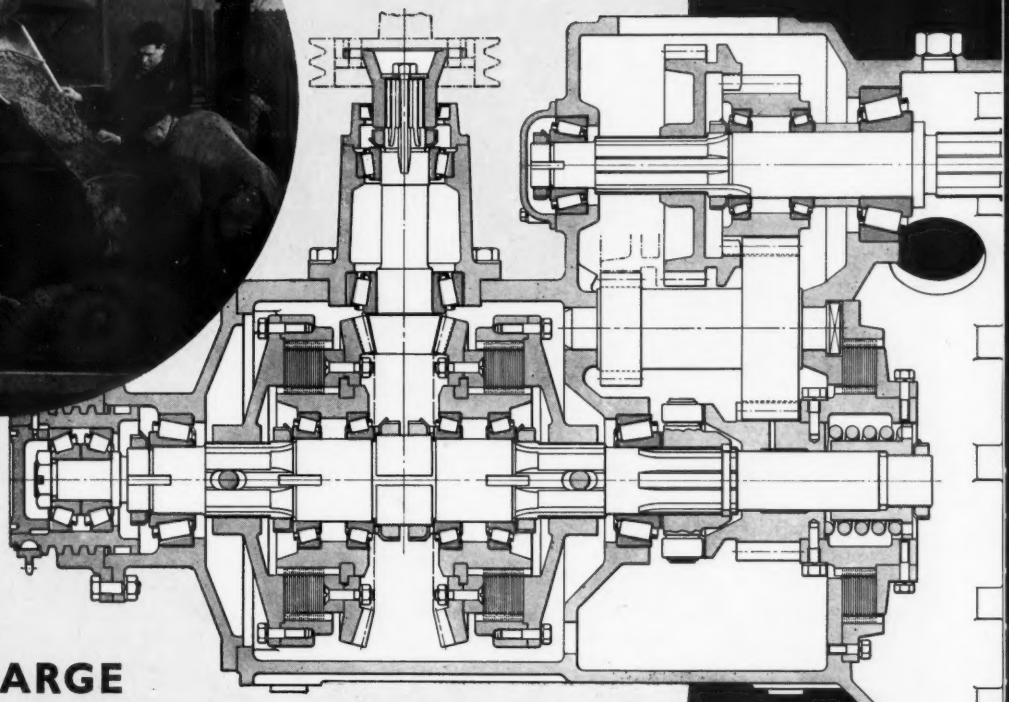
SET-UP FOR MACHINING CONTOURS OF FORGING DIE ON OUR STANDARD COPYING UNIT WITH TEMPLATE MOUNTED ON SADDLE.



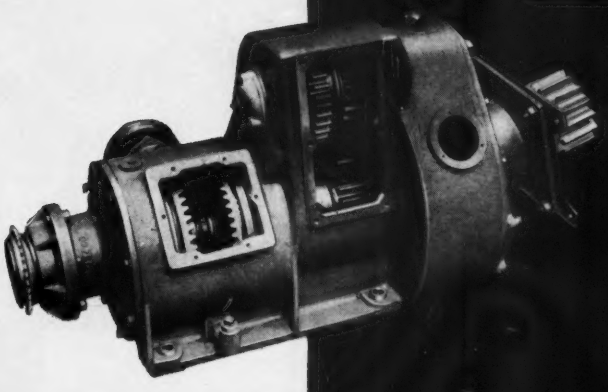


MATERIAL DIE STEEL
60/70 TONS PER
SQUARE INCH

TYPES 13-1, 17, 21, 25, 26 and 30 INCH SWING LATHES



The RAPIER HIGH-DISCHARGE TRUCK MIXER



This device made by Ransomes & Rapier Ltd., Ipswich, mixes concrete and delivers it at a conveniently high level. It is mounted on a commercial vehicle, and is driven by separate gearing.

Interesting features in the mixer transmission system are the multi-disc reversing clutches, one for each crown wheel. As will be seen from the drawing, each crown wheel hub is carried on the shaft by a pair of Timken bearings, and the shaft itself is also carried in the casing by two Timken bearings.

A clutch-operating rod passes through the hollow shaft, coupled, by cross-pins working through slots, to the crown wheel hubs. Engagement of one or other clutch is controlled by axial movement of a chain-rotated sleeve, the necessary running thrust being conveyed through a pair of steep-angle Timken bearings.

Another interesting feature lies in the final 2-speed spur reduction, where the drive from the crown wheels shaft is taken through rollers engaging helically-faced jaws; thus, while torque is being transmitted, the axial thrust set up disengages the multi-disc brake. Directly torque ceases to pass, the brake goes on, automatically preventing spin-on.

TIMKEN Regd. Trade Mark

TAPERED-ROLLER BEARINGS MADE IN ENGLAND BY

BRITISH TIMKEN

LIMITED

DUSTON, NORTHAMPTON (HEAD OFFICE) AND DAVENTRY, NORTHANTS.

engineers everywhere

prefer the 20T

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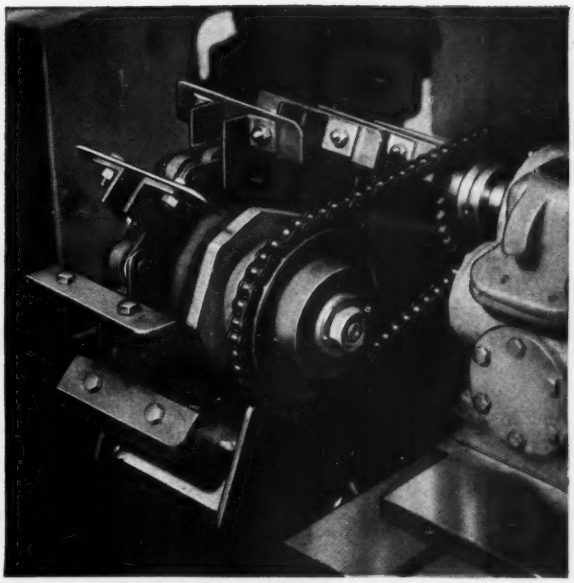
OFF-THE-SHELF SERVICE



A Renold stock drive from the output shaft of gearbox to swarf conveyor headshaft, using .5" pitch simple roller chain. The conveyor is equipped with Renold conveyor chain with F1 attachments.

Specify

RENOLD STOCK CHAIN DRIVES

up to 140 h.p. in a wide variety of ratios

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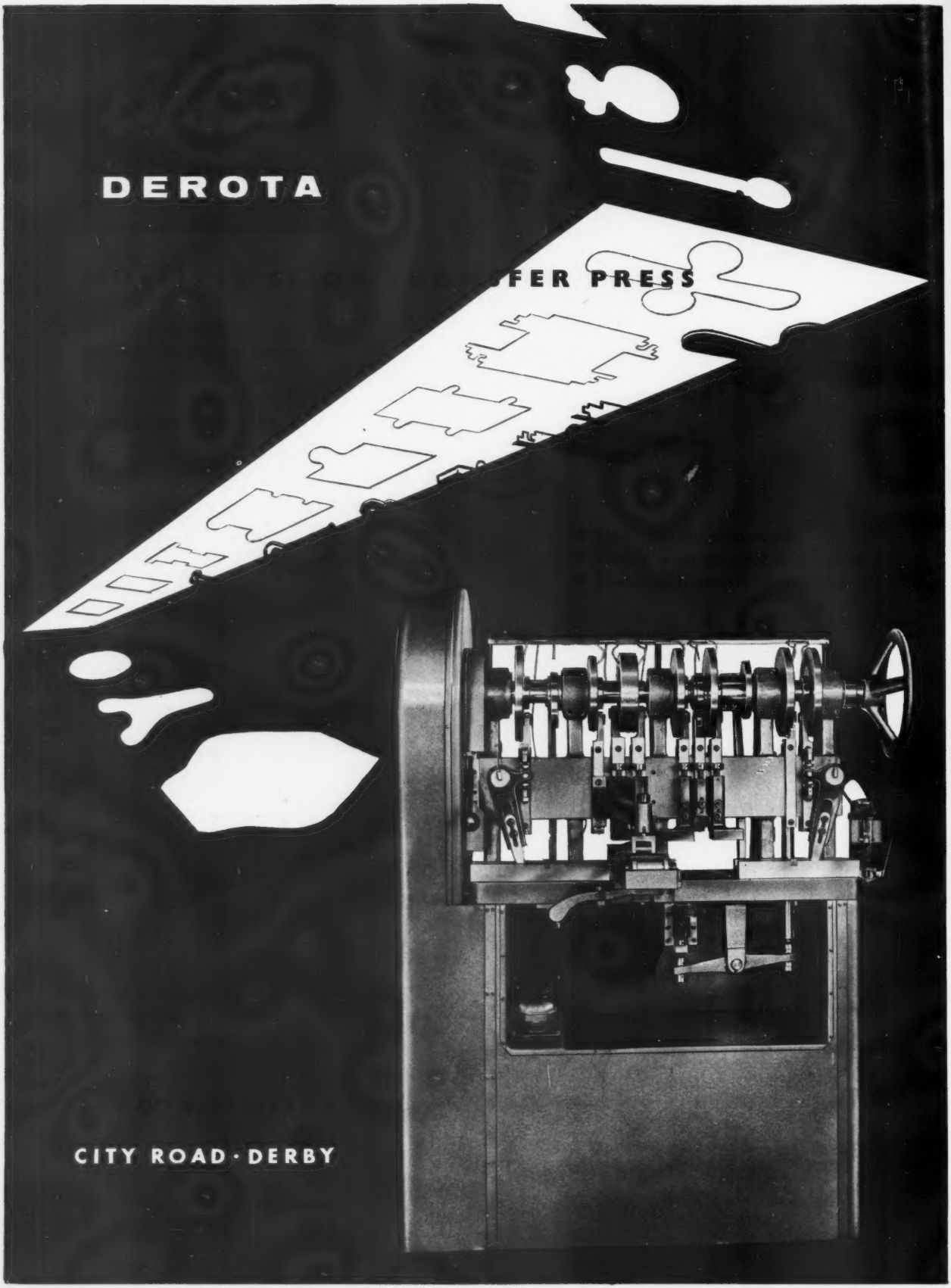
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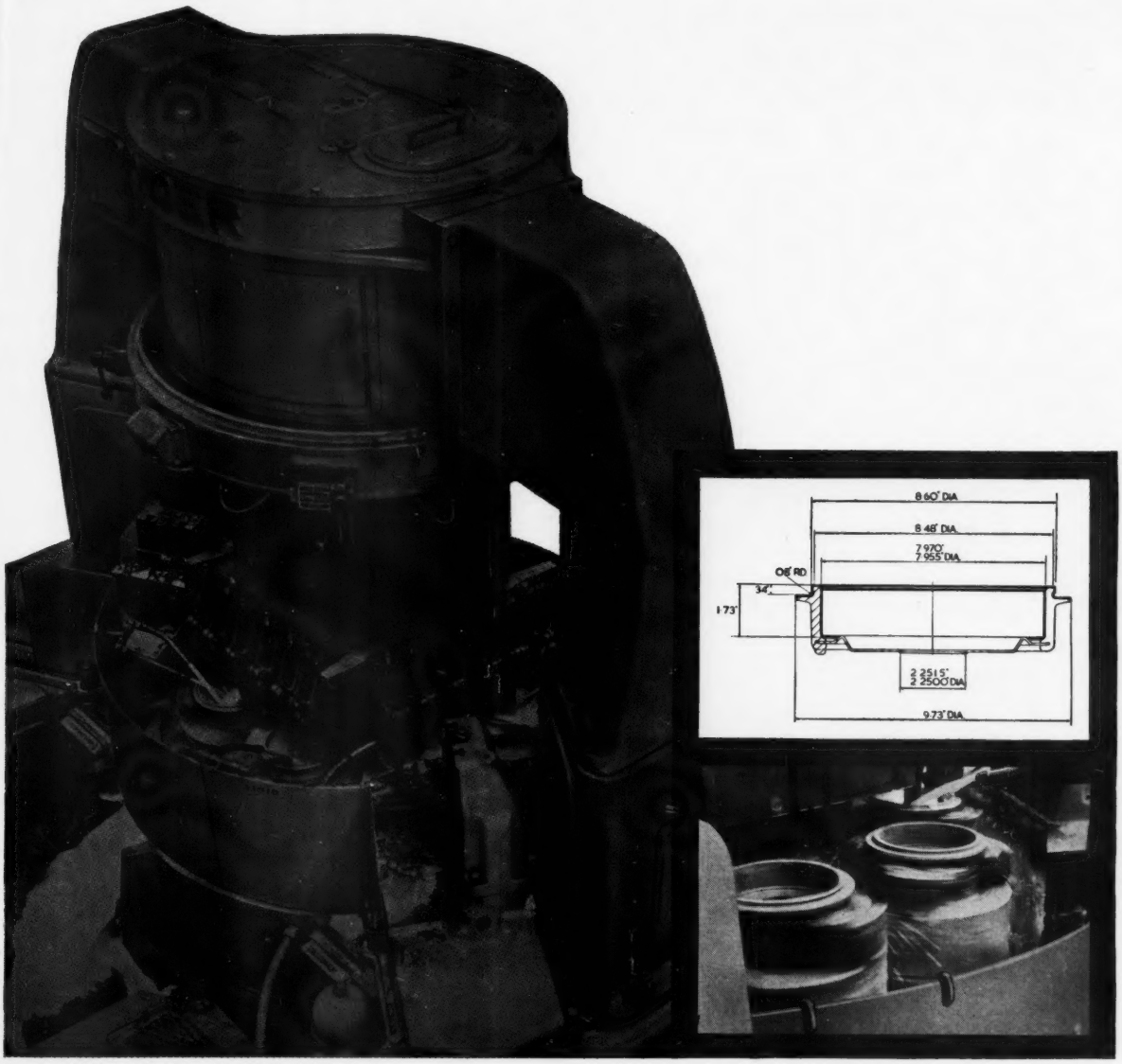

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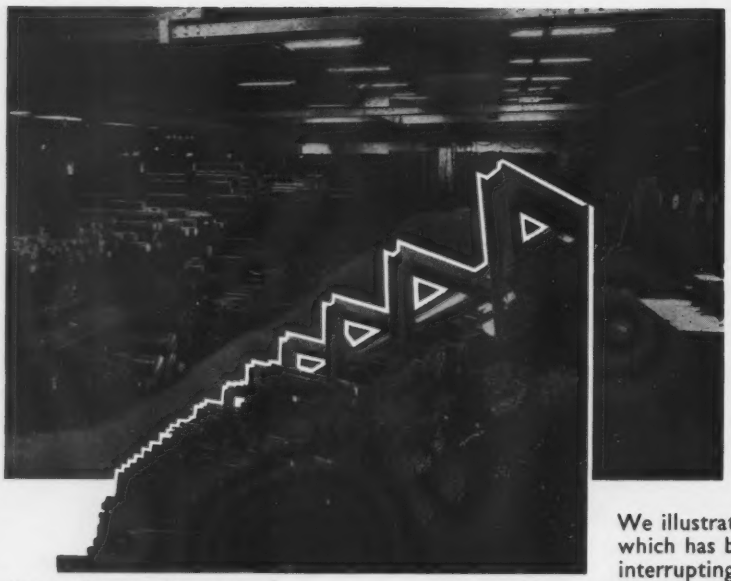

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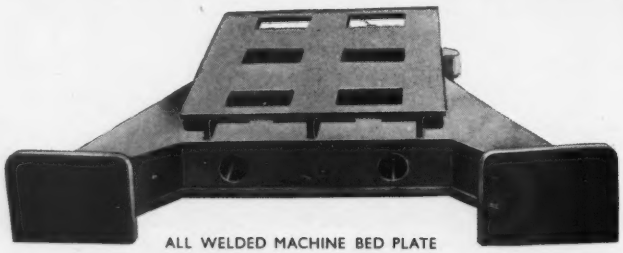

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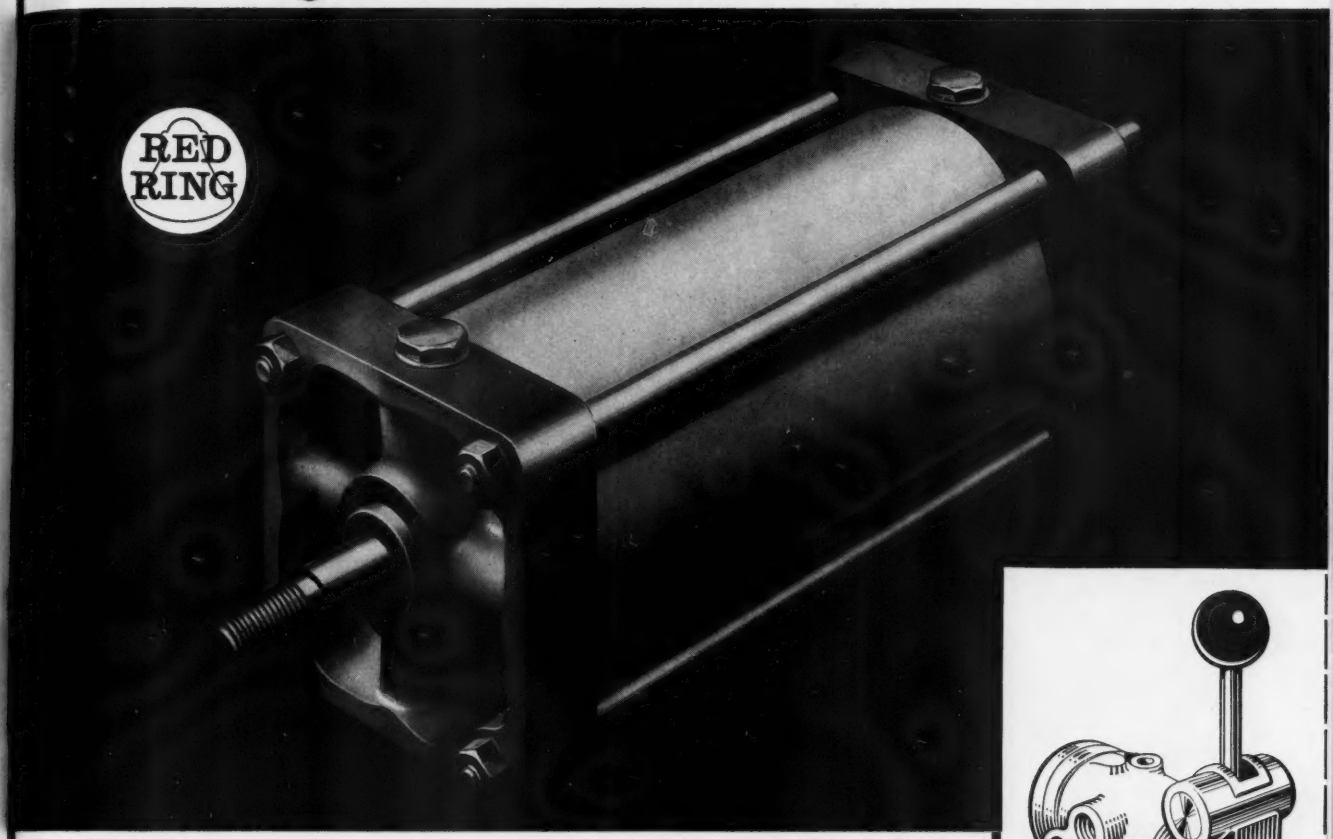

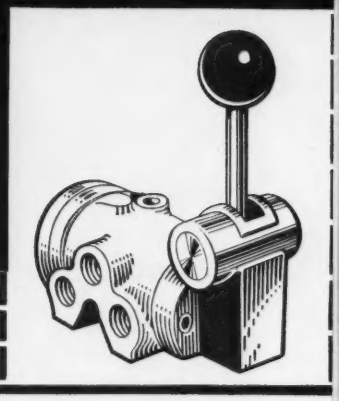

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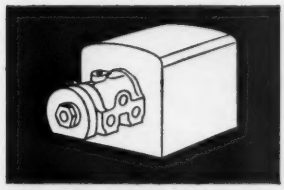

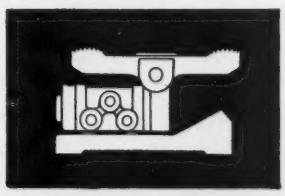

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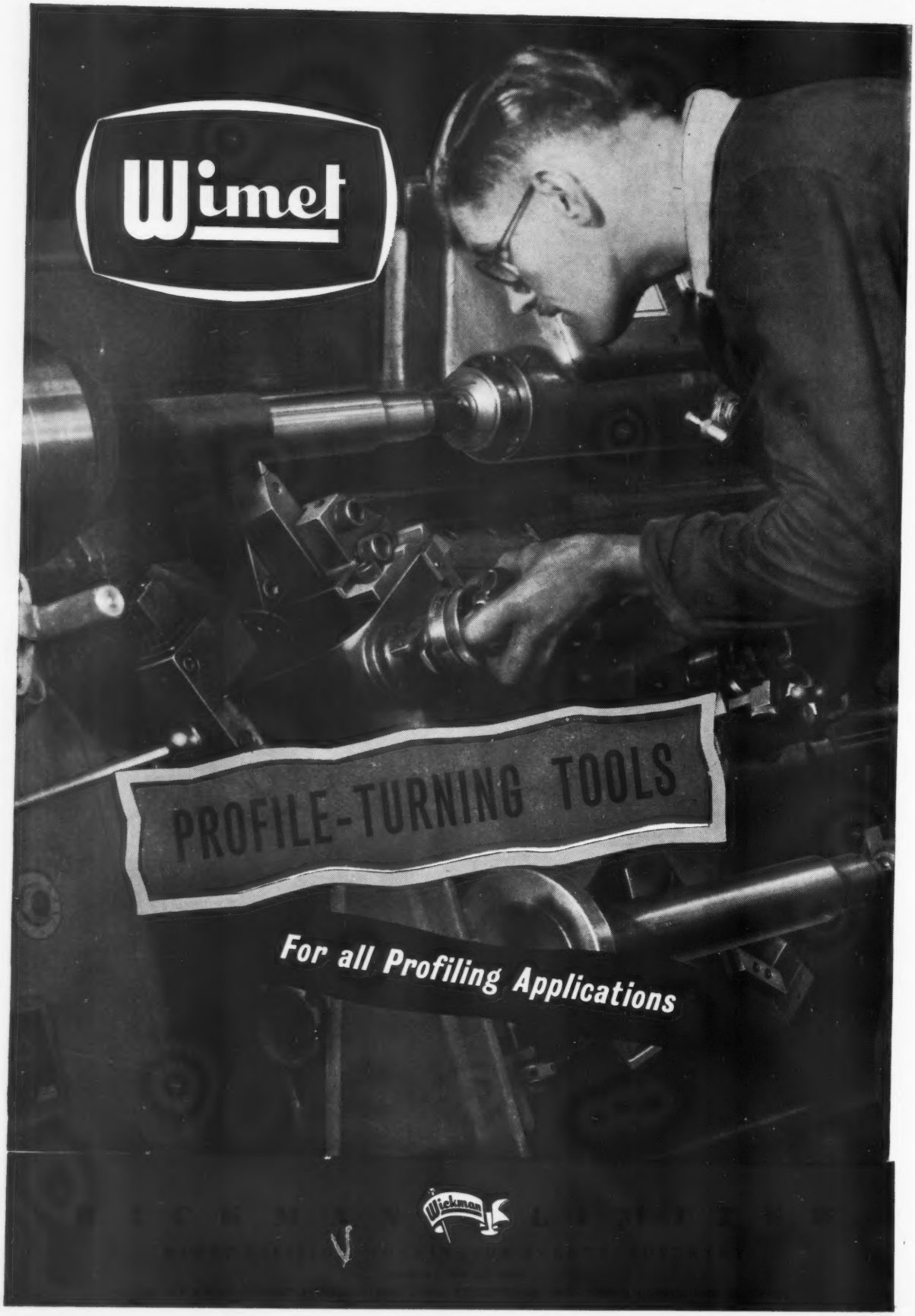
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The Institution of Production Engineers Journal
VOL. 38 NO. 6 JUNE, 1959

Seventh Annual Conference on

"PROBLEMS OF AIRCRAFT PRODUCTION"

University of Southampton, 16th/17th April, 1959

THE Chairman, **Mr. J. B. Turner,** M.I.Prod.E. (*Chairman of the Southampton Section*), speaking at the Opening Luncheon, said :

We have with us today in the University of Southampton the élite of the aircraft industry. They are here to discourse on the fact that the aircraft industry is a national asset, a fact which seems to be escaping the attention of some policy-makers in high places. I am glad to find that the theme of the Conference, which was suggested by a representative meeting of the industry, has attracted such a distinguished array of speakers, including Lord Douglas of Kirtleside, Chairman of British European Airways, who was at the head of Fighter Command at the most critical time in our history; Air Chief Marshal Sir Claude Pelly, Controller of Aircraft, Ministry of Supply, with a distinguished record in the Service; Mr. Peter Masefield, now Managing Director of Bristol Aircraft Ltd. and President-Elect of the Royal Aeronautical Society, a man who has displayed amazing versatility; and Mr. S. P. Woodley, Director of Vickers-Armstrongs and a member of our Institution, who will show how the industry has been an asset in the past.

In the Open Forum which is to be held at the end of the Conference these gentlemen will be joined by Mr. Eric Turner, Chairman and Managing Director of Blackburn and General Aircraft, who is an authority on financial matters and an able contributor to the serious press on the problems of the aircraft industry. These gentlemen have given up valuable time to come here to discuss these problems and point the way to solutions which may well involve change and diversification, which are the common lot of the production engineer.

I extend on behalf of the Institution a hearty welcome to Lady Douglas and Lady Walmsley, whose presence graces our table. The presence of ladies is an innovation on these occasions, and perhaps an omen of the changes which I have mentioned. I now invite the Mayor of Southampton to welcome our guests to this historic city and to the university.

The **Mayor of Southampton** (*Alderman R. R. H. Hammond, O.B.E., J.P.*) :

Your Conference will be concerned with the difficulties which beset the aircraft industry at the moment. When the War ended we all realised that the demand for aircraft for the Forces was bound to diminish, but we hoped that this would be counterbalanced by the development of the civil air lines. This has not proved to be the case. Southampton is very much concerned about the future of the aircraft industry; it is one of our major industries and anything that affects it affects our community. It seems to me that the day cannot be far distant when we shall be able to travel for business or pleasure in a " family air car," and I was pleased to learn

In this group at the reception are (left to right): Mr. S. P. Woodley, M.B.E.; Mr. Eric Turner, Chairman and Managing Director, Blackburn & General Aircraft Ltd.; Professor W. I. Lucas, Deputy Vice-Chancellor, University of Southampton; Mr. J. B. Turner; The Rt. Hon. the Lord Sempill, A.F.C.; Air Chief Marshal Sir Claude Pelly, K.C.B., C.B.E., Controller of Aircraft, Ministry of Supply; and Air Marshal Sir Hugh Walmsley.

that Lord Douglas was travelling by helicopter to this Conference; but the misadventure which befell him in having to land near Basingstoke is an illustration of what I have been told by many of you, that the operation of helicopters and other forms of air transport is still dependent on the weather. We must, however, find a means of travelling by air as we now do by car, because with 500,000 new cars coming on to the roads every year it will soon be quicker to walk than ride! It should not be beyond the ingenuity of the aircraft industry to provide a means of family travel by air.

I offer you all a cordial welcome to Southampton.

The Chairman then introduced **Air Chief Marshal Sir Claude Pelly,** K.C.B., C.B.E., M.C., A.D.C. (*Controller of Aircraft, Ministry of Supply*), who said:

I thank you very sincerely for asking me to come here and for your hospitality. I have no professional qualifications for addressing an audience of this kind, and my only excuse for doing so is that I have a very genuine and personal interest in the theme of this Conference.

I do not wish to bore you by going over events of the last two or three years which are already well-known to you, but it is worth while calling attention to the contrast between the situation which seemed to face the aircraft industry after the publication of the White Paper on Defence in 1957 and that which faces it today. When this first White Paper appeared in 1957 it was widely believed — wrongly, as it turned out — that it sounded the death-knell of future manned military aircraft. In fact, however, by the beginning of 1959 we had authority from H.M. Government to go ahead with three major military projects: the T.S.R.2; a medium-range freighter; and a large long-range freighter, so that at least some water has flowed under the bridges since 1957.

Also, in the research and experimental field, there is a very lively interest in short-take-off and vertical-take-off possibilities and in advanced helicopter designs. In the civil field there has been considerable activity and many of our aircraft firms have committed big resources in terms of design teams, finance and so on to the design and building of civil aircraft. At this very moment the possibility of embarking on supersonic air transport is exercising the minds of many people.

I think, therefore, that it is fair to deduce that there is still much challenging work ahead of the aircraft industry, though we must all admit that some reduction in overall production capacity from the expansion period of the Korean war is inevitable.

The Mayor of Southampton (Alderman R. R. H. Hammond, O.B.E.) has a word with Mr. J. B. Turner (Southampton Section Chairman) and Mr. W. W. Petter, C.B.E., Managing Director, Folland Aircraft Ltd.

Obviously enjoying the luncheon are (from left): Air Marshal Sir Hugh Walmsley, Managing Director, Air Service Training Ltd.; Mr. Peter Masefield; and Lord Caldecote, Director, The English Electric Company Ltd.

Equally, we must all be impressed by the export achievements of the industry. Taking the official Government figures, in 1958 it exported £148,000,000 worth of goods, compared with £110,000,000 worth in 1957, and the curve still seems to be rising.

Some analysis of the contribution which the industry is making to our national status and to progress in the engineering world may be of interest. Taking just a few of the aspects which come to mind, I would mention technical education, management skill, the development of special materials, special production techniques and the design of special machine tools. In each of these sectors, and perhaps more especially in the development of new materials, the aircraft industry has been the pathfinder. It would not, I think, be unfair to claim that in the ten years or so after the War the aircraft industry has stimulated quite a large expansion in the range, quality and productive capacity of the electronic industry, and this is only one example.

Thus, although the importance of the aircraft industry as a supplier of military weapons, a builder of civil aircraft and an exporter of valuable goods is undisputed, its real significance to this country, to my way of thinking, is that it blazes the trail of advanced technical development. Because the specifications for aircraft and aero engines are so exacting, because international competition for airline traffic is so intense, and because the ultimate limits of achievement in aeronautics are a challenge to anyone's imagination, the aircraft industry is always reaching out into the unknown and gathering technical information which others can and do use. It is a question of " always one step more ".

It is for reasons of this sort that I believe the future of this industry is of real interest to the nation. If the industry is to succeed in the face of the intense international competition which now exists, and which will certainly continue, it will clearly have to be well organised and strong in terms of technical competence and also financially. In this international race, it will certainly have the good will and good wishes of everyone here today.

Let me conclude by wishing you a most successful Conference and by congratulating the Chairman and his team on selecting such an important and lively theme for your discussions.

Session I of the Conference followed after a short interval.

Members of the Southampton Section Committee at the reception (from the left) are: Mr. R. C. C. Wadey; Mr. L. A. Daish; Mr. C. Sumner; Mr. J. W. Taylor (Honorary Secretary); Mr. J. B. Turner (Chairman); and Mr. F. T. West, M.B.E.

Seventh Conference on

"PROBLEMS OF AIRCRAFT PRODUCTION"

Southampton, 16th/17th April, 1959

Theme : " The Aircraft Industry — A National Asset

The Seventh Conference on " Problems of Aircraft Production ", promoted by the Southampton Section of the Institution, took place on 16th - 17th April, 1959, at the University of Southampton (by kind permission of the Vice-Chancellor). This issue of the Journal contains a report of the speeches made at the Opening Luncheon, and of the proceedings in Sessions I and II. Sessions III and IV will be reported in the July Journal.

OPENING LUNCHEON

Speakers : The Worshipful the Mayor of Southampton, Alderman R. R. H. HAMMOND, O.B.E., J.P.

Air Chief Marshal SIR CLAUDE PELLY, K.C.B., C.B.E., M.C., A.D.C.

Chairman : J. B. TURNER, M.I.Prod.E., Chairman, Southampton Section.

SESSION I

(The Lord Sempill Paper)

" THE OPERATOR'S POINT OF VIEW "

Speaker : Marshal of the Royal Air Force LORD DOUGLAS OF KIRTLESIDE, G.C.B., M.C., D.F.C., M.Inst.T.

Chairman : The Rt. Hon. THE EARL OF HALSBURY, F.R.I.C., F.Inst.P., M.I.Prod.E., President of the Institution.

SESSION II

" THE INDUSTRY'S POINT OF VIEW "

Speaker : PETER G. MASEFIELD, M.A., F.R.Ae.S., M.Inst.T., F.I.Ae.S., C.I.Mech.E.

Chairman : D. L. WIGGINS, M.I.Prod.E.

SESSION III

" THE IMPACT ON OTHER INDUSTRIES "

Speaker : STANLEY P. WOODLEY, M.B.E., M.I.Prod.E.

Chairman : F. T. WEST, M.B.E., M.I.Prod.E.

SESSION IV

OPEN FORUM — " THE IMPORTANCE OF THE AIRCRAFT INDUSTRY IN THE NATIONAL ECONOMY "

On the platform : LORD DOUGLAS OF KIRTLESIDE; PETER G. MASEFIELD; STANLEY P. WOODLEY; ERIC TURNER, A.C.A.

Chairman : Professor E. J. RICHARDS, M.A., B.Sc., F.R.Ae.S.

THE OPERATOR'S POINT OF VIEW

by Marshal of the Royal Air Force
LORD DOUGLAS OF KIRTLESIDE,
G.C.B., M.C., D.F.C., M.Inst.T.

Chairman,
British European Airways

AT the present time about 650,000 people are employed on aviation activities in the United Kingdom. Rather more than half this number are in the aircraft, aero-engine and associated accessory manufacturing industries; 6% are in the scheduled airlines and the majority of the remainder in the Forces (Table 1). The aircraft, aero-engine and accessory manufacturing industries, therefore, constitute the most important part of Britain's total aviation effort. This industry has earned some £800 million in foreign exchange since the War and is, at present, adding to that total at a rate of about £150 million annually. (Figure 1.) Furthermore, aircraft exports are increasing at a faster rate than United Kingdom exports as a whole. (Figure 2.) The figure of £150 million compares with current earnings abroad by United Kingdom airlines of perhaps £50 million annually. In addition, the aircraft industry provides an essential backing to national defence, while the transport aircraft it produces are potentially as important to Britain's competitive stance in civil air transport as our success in shipbuilding has been to our position as a great maritime trading nation.

The financial risk in aircraft manufacture is, however, so great that this has traditionally always been a primarily Government-sponsored activity in all countries. In the past, the requirements for manned aircraft for defence purposes have been such that aviation has always received, without question, a large proportion of the money spent by Governments on research and development. Military justification for this expenditure is, however, beginning to decline because of the switch which is now taking place to guided weapons. As a result, Governments are having to decide how much they should continue to spend on aircraft research and development under the new conditions of much-reduced defence justification for such expenditure. If Government sponsorship is reduced in proportion to the declining defence interest in manned aircraft, there will be a marked slowing-down in the next few years in the rate of aeronautical progress for civil as well as military purposes.

If a slower rate of progress in aircraft development takes effect in all countries simultaneously, it is unlikely to affect the development of air transport adversely. Indeed, less frequent replacement of transport aircraft by new and more advanced designs is likely to help rather than hinder the healthy economic progress of the airlines. However, if transport aircraft development is slowed down for the above reasons in some countries while it continues at a fast rate in others, there is no doubt that the countries which economise in this way will soon find themselves squeezed out of the aircraft business altogether. They will then become dependent for

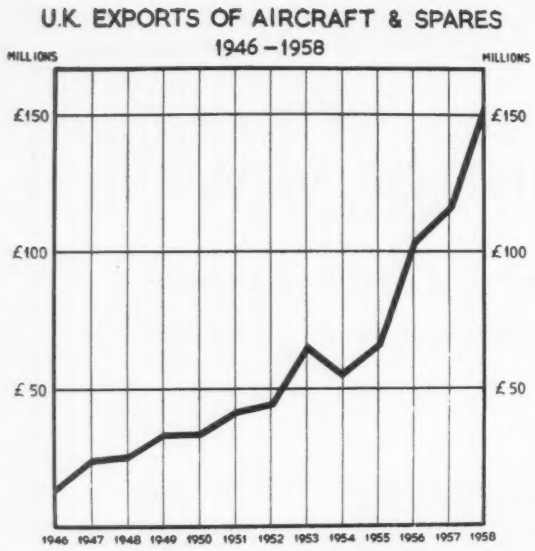


Fig. 1.

Fig. 2.

their civil aircraft entirely on those countries which continue to maintain a high rate of expenditure on aircraft research and development.

This problem is of particular importance to the United Kingdom for three reasons:—

(1) This country has, in the past, played a leading part in aeronautical development because it has been found that this sophisticated field is a particularly favourable one in which to exploit Britain's highly-developed scientific and technical skills. The United Kingdom's success in aircraft development has undoubtedly made an important contribution to the maintenance of our position as a world power which has not had to rely solely on the goodwill of other countries to sustain the military defences which have ensured our political and economic independence.

(2) This country's prosperity in the past has been largely based on our success in international trade, particularly as a carrier of the world's seaborne traffic. With the increasing importance of air transport, it has become apparent that we must take a leading part in international air transport if we are to maintain and advance still further the standard of living in this small and over-crowded island. Manufacture of transport aircraft in this country can

TABLE I

NUMBERS EMPLOYED IN AVIATION ACTIVITIES IN THE UNITED KINGDOM

Activity	Number	Percentage
Aircraft manufacture and repair, including accessory industries	330,000	51
Royal Air Force, Fleet Air Arm and Army Air Corps ...	200,000	31
Airlines (B.O.A.C., B.E.A. and independent operators) ...	40,000	6
Government Departments, Research Establishments and miscellaneous operating and maintenance	80,000	12
TOTAL	650,000	100

provide us with an independence from foreign goodwill in the provision of the vehicles we require for this new trade similar to that provided by home-built military aircraft for defence.

(3) The export of civil and military aircraft provides scope for a type of industrial activity which is well-suited to the United Kingdom's need to exploit its native scientific and technical skills and use them to produce articles which can be sold to countries which, although they may have richer natural resources than ourselves, are less well provided for in the industrial and scientific sense.

The United Kingdom Government has, therefore, to decide whether it can afford to reduce its expenditure on aircraft research and development to the extent which is apparently justified by changing defence requirements. Such a reduction would result in a rate of aeronautical progress in this country which would be quite inadequate to maintain the competitiveness of British transport aircraft unless—as seems unlikely—all other countries reduce their own expenditure in this field to a similar extent.

importance of the aircraft industry

The aircraft industry is important to the overall prosperity of the United Kingdom in many ways, only some of which bear directly on the air transport industry. It is therefore desirable, before considering the matter purely from the airlines' point of view, to examine in rather more detail why the aircraft industry has special claims for consideration by the Government as a branch of industry which is particularly worth fostering. These are:—

(1) *The value of aircraft exports bears a very favourable relationship to the cost of imports of raw materials required for their manufacture.*

Only about 15% of the prime cost of an aeroplane is required to cover the cost of the raw materials needed for its manufacture, and only about a third of these materials has to be imported; 25% covers the cost of complete bought-out items (a large proportion of the value of which is United Kingdom labour cost) and the remaining 60% is the value of the aircraft manufacturers' labour. It is, therefore, probable that something over 90% of the value of an exported aeroplane is " pure export "—largely highly skilled home labour. This ratio compares with an average of about 75% for United Kingdom exports of manufactured goods as a whole.

(2) *The export of aircraft—and particularly of transport aeroplanes—enables a country with a well-established technological tradition, such as the United Kingdom, to benefit to the maximum extent possible from its pioneer work in new fields of technology.*

Britain has been responsible for large numbers of technical innovations in the past and many of these have been in fields related to aviation. Notable examples in recent years are: gas turbines (both pure jets and turbo-props); radar (and many other developments in the field of radio and electronics generally); new manufacturing processes (machine tools, synthetic adhesives, new paints and finishes, new types of structure); and advanced new materials of many kinds (plastics, synthetic rubbers, light alloys, very high-strength steels and heat-resisting materials—some of which, for example, have made major contributions to the development of the gas turbine).

These technical innovations and many others are the result of the inventive genius and the high level of technical skill which has been fostered in this country during the past 150 years since the start of the Industrial Revolution. These are, indeed, among our greatest national assets. The United Kingdom must exploit them to the full for its economic well-being, and the export of aircraft is one of the best ways we can do so.

(3) *Advances in the aeronautical field greatly stimulate progress in other technologies.*

Because aeronautics is one of the most " sophisticated " of the technologies, progress in this field has an important effect on the rate of advance in many branches of industry, even though these may not be directly related to it in any way. A country's competitiveness in international trade in the modern world is controlled to a large extent by the contribution which it makes to scientific and technical progress generally. There is no doubt that aeronautics is one of the " key technologies " from this point of view and that a country which lags in aeronautical development will have its whole technological effort impaired.

(4) *The aircraft industry is one of the most " progressive " in the country and has contributed much which has benefited other industries.*

The aircraft industry has been a leader in many aspects of industrial activity for many years. This applies as much in such fields as manufacturing, inspection, quality control and standardisation techniques as in methods of management and labour relations.

(5) *A healthy aircraft manufacturing industry, which can be turned on to military aircraft and guided weapon production if and when required, is an essential foundation for an effective defence policy. It also provides an insurance against errors in defence policy-making.*

It is difficult, and certainly very expensive, to maintain a prosperous aircraft industry in peace time purely on a basis of military orders. This will become progressively more difficult as the swing continues away from manned aircraft and towards guided weapons. For these reasons, transport aircraft orders, which keep several large manufacturing companies busy, can make an important indirect contribution to the nation's defence resources and to its ability to meet changes in defence requirements as soon as possible after these occur. If the change-over to

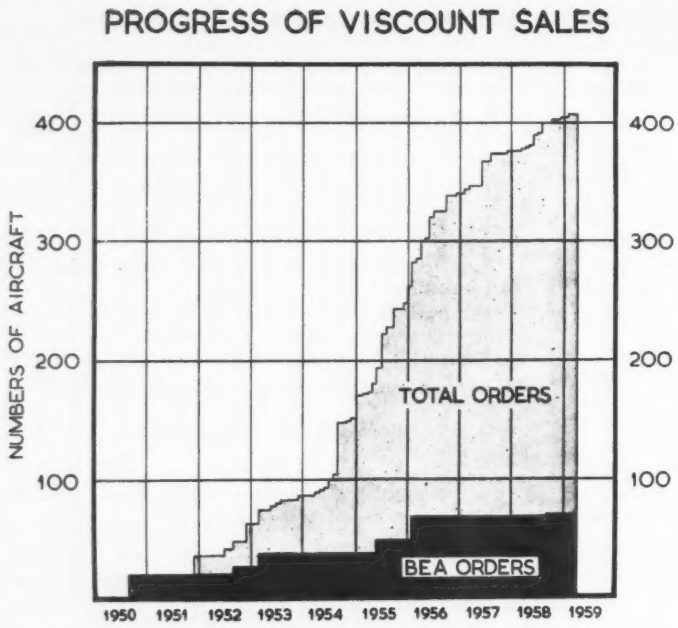


Fig. 3.

guided weapons proves, in the event, to have been too precipitate, the continued existence of an aircraft industry will provide an invaluable insurance.

(6) *A pool of transport aircraft, which can be maintained and expanded from home resources, is of greater defence value than one composed solely of imported aircraft.*

Transport aircraft in service with both civil operators and the R.A.F. are an essential element today in our defence preparations. These transport reserves are of greatest effectiveness if they employ aircraft of British manufacture. Transport aircraft in service can most easily be maintained and repaired and, in addition, can be replaced and reinforced from United Kingdom resources if they are of British manufacture.

(7) *Countries with prosperous shipbuilding industries are at an advantage in developing their seaborne trade. In the same way an aircraft industry which builds effective transport aircraft can provide valuable help to a country developing its air transport.*

A close technical liaison is possible between home operators and manufacturers when the former are using the latter's products. This working together benefits both and should enable the manufacturers to produce transport aeroplanes of maximum effectiveness and export appeal. This is because aircraft so produced will have been designed and built directly for, and in close association with, a large and experienced operator who is immediately interested in the effectiveness and success of the new design. Similarly, the operator benefits from getting equipment designed and built specifically to his requirements. He gains also the competitive, publicity and prestige advantage of introducing the new aircraft before anybody else. On the other hand, he also incurs economic, engineering and operational penalties which will be discussed later in this Paper.

(8) *The restrictions to be overcome in the export of British transport aircraft for use by other nations are less serious than those facing the expansion of the United Kingdom's share of the world's airborne trade.*

Exported British aircraft have to face straightforward competition on their merits from, at the moment, chiefly American aircraft. Competition, on a limited front, is growing from France and Holland while the Soviet Union may possibly become a powerful contender within the next decade. However, the problem is one of relatively unrestricted competition. When a British transport aircraft is clearly superior to its competitors, it can—as the Viscount has shown—win world-wide sales. (Figure 3.)

The obstacles to the expansion of Britain's share of the world's airborne trade are more intractable. Unlike shipping, which operates in a " Freedom of the Seas " environment, air transport is strictly controlled by an intricate network of international bilateral agreements between Governments, which often have the effect of limiting a nation's share of traffic to a maximum of 50% of the total on the routes concerned.

The United Kingdom at present carries 5% of the world's total air traffic. This percentage compares unfavourably with our 30% share of the world's seaborne trade. (It is, however, relevant to note that the latter figure is unlikely to be maintained if the

current diversion of sea trading to " flags of convenience " continues.) There are well-known historical reasons for the United Kingdom's ascendancy in shipping. There are equally good explanations of our slow start in air transport, compared with the United States, after the Second World War. The Americans provided the major share of Allied air transport capacity during the War and this enabled them to establish themselves in a strong position immediately it was over. Today they still carry 35% of international air traffic, compared with the United Kingdom's 14%. In addition, U.S. domestic air traffic alone represents no less than 50% of the world total. These percentages are all related to total traffic in the Western World and exclude Russia and China. No precise figures are available for these two countries, although there are indications that their air traffic may now be approaching a level equivalent to about 30% of that in the West.

(9) *Use of British aircraft by British and foreign operators has considerable prestige and publicity value to the United Kingdom which brings numerous indirect benefits to British industry as a whole.*

The operation of high-quality British transport aircraft by United Kingdom operators in foreign countries is one of the most effective ways of " showing the flag " in the modern world. Just as visits of British warships to foreign ports have always been recognised as a most effective way of advertising the nation's world-wide interests and influence, so, under present-day conditions, British transport aircraft in the colours of a United Kingdom operator are a powerful advertisement for their country of origin. Thus, there is no question that, during its period of operation, the Comet 1 was a most valuable source of prestige and publicity to the United Kingdom, particularly in the countries through which it operated. Use of British aircraft by foreign operators is a less effective advertisement of the United Kingdom to the man-in-the-street, but it remains of great value as a means of boosting British prestige with administrations and with influential people who are sufficiently technically well informed to be aware of the country of origin of the aircraft used by the airlines serving their area.

the " fly British " policy

A Government White Paper of March, 1945, about " British Air Transport " (Cd. 6605) stated that it was " the intention of His Majesty's Government that the Corporations shall use British aircraft as soon as they can be made available."

TABLE II

NUMBERS OF TRANSPORT AIRCRAFT
In scheduled airline service or on order as at January 1, 1959.
(Aircraft with a maximum take-off weight of more than 20,000 lb.)

	Number in service	*Number on order*
U.S. Aircraft		
Boeing B.307 Stratoliner	10	—
B.377 Stratocruiser	44	—
B.707/720	8	174
Convair CV-240	124	—
CV-340	190	—
CV-440	126	5
Catalina	17	—
CV-880/600	—	87
Curtiss C-46 Commando	213	—
Douglas DC-3	1,459	—
DC-4	285	—
DC-6, 6A, 6B, 6C	499	6
DC-7, 7B, 7C	302	—
DC-8	—	140
Fairchild C-82 Packet	13	—
F.27 Friendship	24	24
Lockheed L.049	60	—
L.749	111	—
L.1049	235	1
L.1649A	43	—
Electra	7	143
Martin M.202, 202A	32	—
M.404	93	—
Miscellaneous U.S. Aircraft	27	2
TOTAL U.S. AIRCRAFT	3,922	592
British Aircraft		
Avro Tudor	6	—
York	15	—
Bristol 170	51	—
Britannia 100	15	—
Britannia 300, 310	32	6
de Havilland Ambassador	6	—
Comet 4	6	21
Comet 4B	—	6
D.H.121	—	24
Handley Page Hermes 4	17	—
Short Sandringham	8	—
Solent	1	—
Vickers Viking	64	—
Viscount 700	245	5
Viscount 800	94	26
Vanguard	—	40
VC-10	—	35
TOTAL BRITISH AIRCRAFT	560	163
Aircraft other than U.S. and British		
Breguet 763 " Deux Ponts "	12	—
Canadair DC-4M	41	—
Fokker F.27 Friendship	4	39
Ilyushin Il-14	7	—
Nord Noratlas	10	2
Saab Scandia	16	—
Sud-Aviation Languedoc	5	—
Caravelle	—	50
TOTAL AIRCRAFT OTHER THAN U.S. AND BRITISH	95	91
AMERICAN SHARE OF WORLD TOTAL	86%	70%
BRITISH SHARE OF WORLD TOTAL	12%	19%
GRAND TOTAL	4,577	846

This policy is a continuation of that followed since the start of civil aviation in 1919. After the formation of Imperial Airways Ltd. as the first "Chosen Instrument" British airline in 1924, the "Fly British" policy was followed throughout the inter-war years. The British aircraft used by Imperial Airways remained at least as competitive and effective as the best contemporary foreign aircraft until the middle 1930's, but from that date, when the Americans started to produce the first modern all-metal cantilever monoplane transports, the United States have gained a controlling position as the world's main suppliers of transport aircraft. Today 86% of the transport aeroplanes in main-line scheduled service are of American manufacture (Table II). American success in this field in the past 30 years has been due to a policy of producing efficient and economic aircraft designed in the first place for the U.S. airlines, but which are also suitable for world-wide use and have, in consequence, been ordered by operators in many countries. This policy continues to this day.

In looking back over the history of air transport, it is significant that even the most successful British transport aircraft of the inter-war years failed to sell widely in the export market because they lacked those generally-acceptable qualities of appropriate size, economy and performance which would induce foreign operators to buy them. As a result, British airliners, even in their most successful period (1919-1931), were built in only small numbers mainly to the special order of the one major British operator—rather in the way that a few ocean liners of similar design are bought by individual shipping companies.

A second major United Kingdom airline, British Airways Ltd., appeared soon after the first American monoplane transports in the mid-1930's. In the years immediately preceding the last War, this company emerged as an important competitor to Imperial Airways in Europe, using American equipment. In this way, the deficiencies of the out-dated British aircraft used by the original "Chosen Instrument" were highlighted, and this led in turn to a change in Government policy and the amalgamation of Imperial Airways and British Airways into B.O.A.C. in 1940. The Government's intention at that time was that the new nationalised Corporation should use new British equipment of comparable design to the American monoplanes. However, this policy was interrupted by the War. In the event, B.O.A.C. used American aircraft and such adaptations of British military designs as could be made available between 1940 and 1945.

During the War, the manufacture of transport aircraft was stopped altogether in Britain and the Americans were left to establish themselves as world leaders in this field without any foreign competition. Since the War, the United Kingdom has re-entered the field and our aircraft policy has taken account of the fact that, if we are to build up a worthwhile business in this field, we must produce transport aeroplanes which are suitable for operators all over the world and not just for the home airline which first orders them. Only by so doing can sufficient orders be obtained of individual designs to make their manufacture profitable.

In conformity with the policy set out in the White Paper, B.O.A.C. and its two sister Corporations, B.E.A. and British South American Airways which were formed at the end of the War, have been expected to use only British equipment. However, it was soon found in the immediate post-war years that some foreign aircraft had to be used, at least for an interim period until new British aircraft could be developed, if British airlines were to survive and build up their traffic in the face of foreign competition. As a result B.E.A.—and, for a short period, B.O.A.C.—have used war-surplus American DC-3's. In addition, B.O.A.C. (which absorbed B.S.A.A. in 1949) has ordered American Constellations, Stratocruisers, DC-7C's and Boeing 707's as well as Canadian-built Argonauts of American design. These aircraft have maintained the majority of its services during the past 12 years. Indeed, British aircraft have contributed only 30% of B.O.A.C.'s total output since the War. The American types have been necessary because the first British aircraft developed for B.O.A.C. proved to be unsatisfactory, later types

TABLE III

POST-WAR AIRCRAFT PURCHASED BY B.O.A.C.

Aircraft type	Country of origin	Date of first service	Years in service	Number ordered
York	British	16. 3.44	10¾	34
Constellation 049	U.S.A.	1. 7.46	9	8
Sandringham ...	British	2. 5.47	2¼	31
Solent ... †	British	27. 2.48	2¾	16
Constellation 749	U.S.A.	1.12.48	10	16
Argonaut ...	Canada	23. 8.49	9¼*	22
Stratocruiser ...	U.S.A.	7.12.49	9¼*	17
Hermes 4 †	British	6. 8.50	4¼	20
Comet 1 †	British	2. 5.52	2	11
DC-7C ...	U.S.A.	6. 1.57	2¼	10
Britannia 102 †	British	1. 2.57	2¼*	15
Britannia 312 †	British	19.12.57	1¼*	18
Comet 4 †	British	4.10.58	¼*	19
Boeing 707 ...	U.S.A.	Winter 1959/60	—	15
VC-10 ... †	British	Early 1964	—	35
				287

† types initally sponsored by B.O.A.C.
* still in service

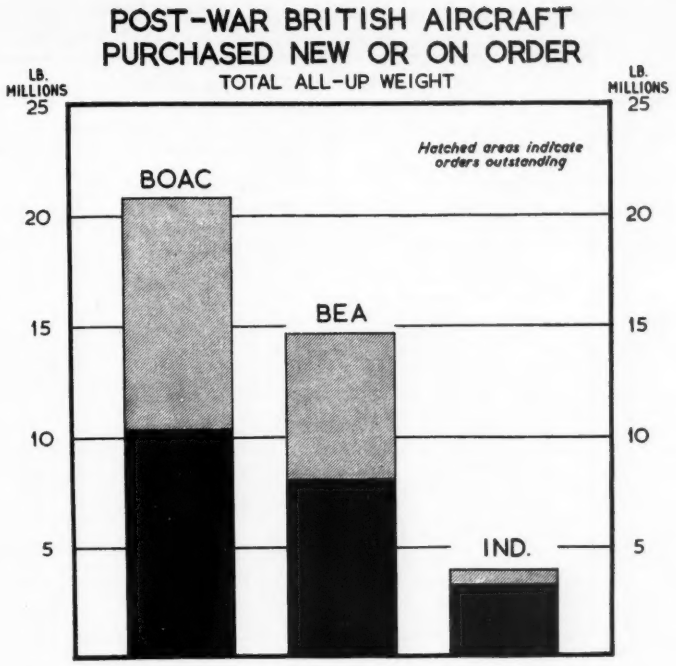
TABLE IV

AIRCRAFT PURCHASED NEW BY B.E.A.

Aircraft type	Country of origin	Date of first service	Years in service	Number ordered
Viking ... †	British	1. 9.46	8	77
Elizabethan †	British	13. 3.52	6¼	20
Viscount 700 †	British	19. 4.53	6*	27
Heron	British	4. 3.55	4*	3
Viscount 800 †	British	13. 2.57	2*	43
Comet 4B ...	British	Spring 1960	—	6
Vanguard †	British	Summer 1960	—	20
D.H.121 †	British	Spring 1964	—	24
			TOTAL	220

† types initially sponsored by B.E.A.
* still in service.

Fig. 4.



were delayed and a decision to order a British long-haul jet was not taken until after large numbers of American jets had been bought by airlines all over the world (Table III). B.E.A. has been more successful in adhering to the "Fly British" policy and all the new transport aircraft purchased since the Corporation was formed have been of British design and manufacture. British aircraft have produced 75% of B.E.A.'s total output since 1946 (Table IV and Figures 4 and 5).

transport aircraft development since the War

Some 25 distinct types of British transport aeroplane have been put into production and sold to airline operators since the last War (Table V). Eight of these have been small feeder types, which in continuation of British successes in this field before the War have sold well, and three have been flying boats. However, neither the small types nor the flying boats have played any major part in scheduled air transport and are therefore ignored in the discussion which follows. The remaining 14 designs were major transport aeroplanes but, of these, only three—the Vickers-Armstrongs' Viking, Viscount 700 and 800—have been really successful as civil transports, in that over a hundred of each have been sold to airlines at home and abroad. Some of the other major designs were, it is true, a success as production articles from their manufacturer's point of view, but only because of the numbers sold to military and other non-airline customers. From the aspect of the airline operator, only three types can be regarded as unqualified successes and two of the three—the Viscount 700 and 800—are basically the same design.

Fig. 5.

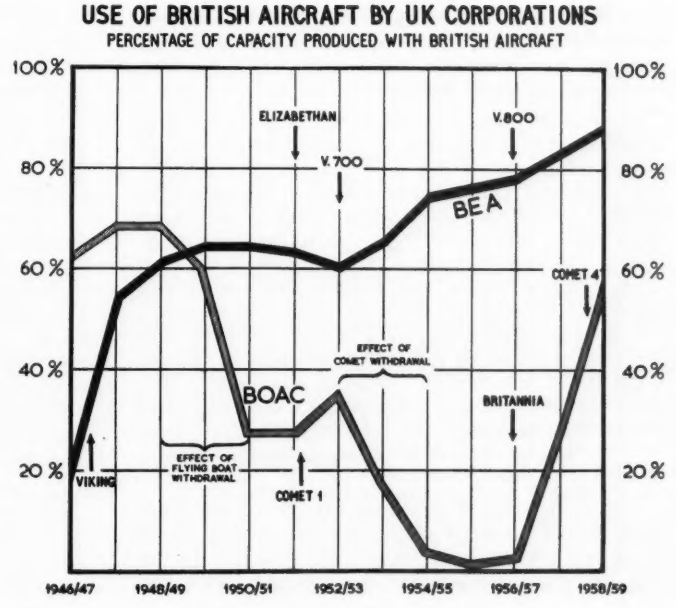


TABLE V

POST-WAR BRITISH CIVIL TRANSPORT AIRCRAFT

Aircraft type	First airline operator	Date of first service	Deliveries and orders outstanding		
			Civil	Export	Total
Airspeed Consul	British Air Transport ...	5.46	24	76	173 (i)
Ambassador... ...	B.E.A.	13. 3.52	20	—	23
Avro XIX	Railway Air Services ...	12.45	41	17+	326 (ii)
Tudor 4B	B.S.A.A.	1.10.47	27 (iii)	—	34 (iii)
Bristol 170	Jersey Airlines	1. 7.46	95	174	210
Britannia 100	B.O.A.C....	1. 2.57	15	—	17
Britannia 300	B.O.A.C....	19.12.57	22	16	68
de Havilland Dove	C.A.A.	12.46	107	403	503
Heron	N.Z.N.A.C.	7.52	82	102	134
Comet 1 ...	B.O.A.C....	2. 5.52	19	10	21
Comet 4 ...	B.O.A.C....	4.10.58	27	8	27
Comet 4B ...	B.E.A.	Spring 1960	6	—	6
D.H. 121 ...	B.E.A.	Spring 1964	24	—	24
Handley Page Hermes 4 ...	B.O.A.C....	6. 8.50	25	29	154 (iv)
Marathon ...	W.A.A.C.	8.52	12	12	40
Hunting Prince (v)	Aeronorte	3.50	31	92	203
Scottish Aviation Twin Pioneer	K.L.M.	26. 6.57	27	25	67
Short Sandringham	Dodero	2.46	33	22	33 (vi)
Solent	B.O.A.C....	4. 5.48	19	4	19
Sealand	West Norway Airlines ...	7.50	2	23	24 (vii)
Vickers-Armstrongs					
Viking	B.E.A.	1. 9.46	161	65	585 (viii)
Viscount 700	B.E.A.	19. 4.53	282	250	282
Viscount 800	B.E.A.	13. 2.57	124	71	124
Vanguard	B.E.A.	Summer 1960	40	20	40
VC-10	B.O.A.C....	Early 1964	35	—	35
	TOTALS		1,300	1,419+	3,172

REMARKS:

(i) These aircraft were all conversions of Oxfords, of which 8,751 were built.
(ii) 11,020 Ansons were built in all.
(iii) Various marks of Tudor.
(iv) Total orders include Hastings.
(v) Including Pembroke and President.
(vi) These aircraft were all conversions of Sunderlands, of which 789 were built.
(vii) Some of these aircraft were conversions of Seafords, of which 30 were built.
(viii) Total orders include Valetta and Varsity.

It is significant that all three successful aircraft are products of the same manufacturer (Vickers-Armstrongs) who developed them in association with the same operator (B.E.A.).

During the post-war years the Americans have produced three major series of successful piston-engined transport aeroplane: the Douglas DC-6/7, the Lockheed Constellation and the Convair CV-240/440, of which some 800 to 1,000 of each have been built, the majority for scheduled operators. They constitute the bulk of transport aircraft in airline service today. In addition, the Americans have built two less widely-sold piston-engine types, the Boeing Stratocruiser and Martin 202/404, and are now engaged in meeting substantial orders for three major jet transport designs, the Boeing 707, the Douglas DC-8 and the Convair CV-880/600 and one turbo-prop design, the Lockheed Electra. These aircraft have all been ordered in substantial numbers by airlines in many countries.

The only conclusion which can be drawn from these simple but unpalatable facts is that the United Kingdom has not been particularly successful in the first phase of its attempt to compete with the Americans and establish itself as a major producer of transport aircraft. If we are to do better in the future and, as has been suggested in the first part of this Paper as a nation we cannot afford to do otherwise, we must apply the lessons of the past 13 years and adjust our policies so that they take account of the lessons and experience which have been so dearly bought.

The main lessons to be learnt from the past would seem to be that:—

(1) Our aircraft manufacturing resources should be concentrated on a narrower front in the civil field. In the past, the United Kingdom has attempted to develop and market too many overlapping types of major transport aeroplane.

(2) Greater effort must be directed at developing British transport aircraft more rapidly and more thoroughly. A greater initial investment is required on the development of new designs, so as to have a larger number of each new type available for test and development flying before it obtains its Certificate of Airworthiness and enters airline service. More ground

testing of components is essential and more intensive and extended flight testing is needed to eliminate defects, so that these can be exposed and corrected before passenger-carrying operations start.

(3) No British firm should be expected to undertake more than one major transport design simultaneously. In this connection, it is significant that no American manufacturer—even such large companies as Boeing, Douglas, Convair or Lockheed, which have several times the resources of the largest British firms—has, in the past, undertaken the successful development of a second basic design of large transport aeroplane while still engaged in the full-scale development of its previous major civil type.

(4) Every new British transport aeroplane should be developed in close association with a United Kingdom airline, which should also be the first operator of the type. Under present conditions, it is most unlikely that a successful airliner can be developed without a wholehearted manufacturer/operator association. This joint effort must extend from the initial framing of the new design to meet an agreed specific requirement right through the subsequent development, and must continue during the aircraft's service life.

(5) Arrangements are required for Government support of the development of certain important types of transport aeroplane in categories which can be expected to have good export prospects, although they are unlikely to be of interest to either of the British Airline Corporations as *major requirements*. B.E.A. and B.O.A.C. might order small numbers of such aircraft " off the shelf " to meet *secondary requirements*, if they are first developed and initially brought into service at the Government's or some other airline's expense. There should be Government sponsorship of the development of such types, together with financial assistance to a selected United Kingdom airline—be it Corporation or independent—which undertakes the role of first operator.

(6) For the next decade, we should concentrate primarily on the " bread-and-butter " types which will carry the great bulk of the world's air traffic for a considerable period ahead. In current circumstances, the subsonic jet is becoming the " bread-and-butter " type for trunk-route services, while the turbo-prop is falling into place as the powerplant for smaller second-line aircraft and possibly, in the larger sizes, for certain low-fare and freight services.

(7) The development of longer-term projects (supersonics, vertical take-off and landing, boundary layer suction, etc.) should not, of course, be neglected if we intend to continue in the aircraft manufacturing business. The next major step in transport aircraft developmen will be to supersonic designs, but this step will not be taken for some years. Because of the enormous technical problems to be solved, development of supersonic transport aircraft will have to be started soon if we are to compete in the next era of aircraft manufacture, but the airlines will not be able to introduce these new types into general service until after they have obtained an adequate return on their current very large subsonic jet investment. For the time being, supersonic aircraft and other advanced projects *must* take second place to the primary objective of completing development and then selling the " bread-and-butter " types to which the United Kingdom is already committed. Failure to do this would be disastrous, but is an easy mistake to make in a business which is as spectacular and swift-moving as aircraft development. There is always a strong temptation to go for something better. We should remember, however, that the airlines are naturally cautious about radical developments. They prefer something which, while being competitive, they can be reasonably sure will work satisfactorily. The airline industry is now committed—probably for a period of between 10 and 20 years—to the subsonic jets which are just beginning to come into service.

the operator's part in transport aircraft development

Very few airlines specifically involve themselves, as a deliberate act of policy, in sponsoring the development and initial introduction into service of new types of transport aeroplane. In an article in " Shell Aviation News " (December, 1956) Mr. B. S. Shenstone, B.E.A.'s Chief Engineer, suggested that there are, in fact, only seven out of about 200 airlines in the world which, at the present time, come into this category. He listed them as: American Airlines, Air France, B.E.A., B.O.A.C., Pan American, T.W.A. and United. B.E.A. and B.O.A.C. are in this category because of the " Fly British " policy and their " Chosen Instrument " status. They thus form an integral and essential part of the British effort to develop and sell new transport aircraft. Tables III and IV set out the types in the development of which the two Corporations have been involved since the War. Although a close manufacturer/operator association is almost essential to the success of a new transport aeroplane, such an association is not, of course, of itself sufficient to guarantee success.

An operator's contribution to the development and introduction into service of a new aircraft type can be summarised as follows:—

(1) He works with the manufacturer on the drawing up of the detailed specification and on the contract which is to be based on it. He starts doing this during initial project work on the new design, and negotiations usually continue

up to the time when the contract is signed. The work requires, in the engineering field, the part-time attention of the airline's chief engineer, of his chief project and development engineer and of a considerable number of specialised staff, notably:—

Performance engineers

Weights engineers

Engine development engineers

Aircraft development engineers

Technical authors.

In addition, a type engineer will be required who gives his full-time attention to the particular aircraft under development.

(2) In the field of contract negotiation, part-time attention is required from the airline's purchasing manager, from his assistant purchasing manager (in charge of contracts) and from several members of his staff who are involved in actual negotiations with the aircraft, engine and component manufacturers and who draw up, agree and finalise all the details of the contract before signature.

(3) In addition, staff in the flight operations, traffic and commercial departments of the airline are brought in at this stage in the consultations which are essential before all the detailed features of the aircraft can be settled to the satisfaction of the airline.

(4) Overall supervision and monitoring of the progress of negotiations is required from the airline's legal department and from its Board and senior policy-making officials.

(5) Once the contract has been signed, the engineering activities covered in (1) above are continued at a high level of intensity as design work progresses and as construction of the first aircraft gets under way.

(6) Much attention is given at this stage to the problems of design for easy maintenance and accessibility, good interchangeability, incorporation of components and accessories of adequate reliability and overhaul life, proper design of the basic structure and of panels, hatches, fuelling points, etc., for durability and efficient operation under all conditions of adverse weather, poor lighting or inadequately skilled labour which may handle the aircraft at outstations.

(7) Also involved during this stage are flight operations specialists (concerned with the instruments and equipment installed and layout of the " front end "), traffic specialists (who are interested in those features of the design connected with the loading and servicing of the aircraft on the ground, with the catering facilities, cabin interior layout and the design, positioning and dimensions of holds, hatches and loading doors) and commercial staff (who are concerned with the standards of passenger seating, catering and accommodation provided in relation to the type of service dictated by the airline's commercial policy; the latter being modified at frequent intervals by changes agreed internationally at the twice-yearly I.A.T.A. traffic conferences).

(8) The airline may become involved at this stage in power plant development undertaken by the engine manufacturer, if a new type of engine is to be used in the aircraft. The airline's contribution may involve the secondment of flying staff and engineers, who will work closely with the manufacturers on the development flying of the new engine. A simulated airline operation with one or more test-bed aircraft may be needed over a period of many months.

(9) Once the aircraft itself begins its test, development and proving flying—up to, and after, the granting of the Certificate of Airworthiness—flying staff and maintenance and performance engineers from the airline will be co-operating closely in this flying at home and abroad. The latter is undertaken for the hot climate, high altitude and icing trials which are required before full certification.

(10) Work has now to be undertaken by the airline in such fields as:—

Spares provisioning

Preparation of maintenance schedules

Preparation of inspection schedules

Maintenance planning of a general nature

Training instructors for ground training

Flight operations planning (flight deck lay-out, instruments and equipment requirements, as well as flight planning data, etc.)

Schedules planning

Traffic planning (aircraft interior, load handling facilities, etc., as well as station organisation and equipment appropriate to the new type).

(11) Finally, before the aircraft enters service, there is often much to be done in the provision of special tools and equipment required by the new aircraft and in the training of staff in all departments in the techniques of the new type's operation. This is done partly during a period of non-revenue-earning development flying which will amount to at least 200 hours, but may be considerably more.

(12) After the aircraft enters service, many of the engineering activities during the development

phase, which have already been mentioned, must be maintained throughout the aircraft's service life—particularly during the first few years while the " bugs " are being got out of the design. This follow-up operation in service is absolutely essential if the aircraft is to be perfected to a level of reliability, efficiency and economy competitive with that of other successful widely-used designs. Important results of success in this field are increases in the overhaul lives of the engines and other components, lengthening of periods between checks and an increase in the intensity of utilisation.

(13) As the aircraft consolidates itself in service, changing operational and commercial circumstances as well as engineering and operational deficiencies—as these reveal themselves—will probably dictate the introduction of major as well as large numbers of minor modifications. These must be planned and executed by an operator who has every incentive to make the best use of the aircraft, because it is equipment on which he has already spent a great deal and to the success of which his own prosperity is largely tied.

(14) If the new aircraft is a success, the first operator has an important role to play in encouraging sales to other airlines. He has a strong incentive to do this because of the disadvantages of having to operate a fleet of " orphan " aircraft which their manufacturer has abandoned in favour of some new interest because he has failed to obtain further sales. The first operator helps to sell the new type by making his operating statistics and results available to potential customers and by giving help and advice with such cost, engineering and operational analyses and other studies as they may wish to undertake. When other operators buy the aircraft, the " parent airline " is often brought in to advise them on engineering and operational planning matters and to provide flying and technical training. These activities are, of course, done under contract but, on balance, the first operator almost certainly devotes more time and effort than he is paid for in helping the manufacturer to sell his product.

Some of the later functions listed above must, of course, be undertaken by all operators of new aircraft, even of a type previously operated and established in service by some other airline. An operator buying an aircraft " off the shelf " rarely escapes all troubles. There are always problems to be overcome when adding a completely different type of aircraft to an operator's fleet, and the newer the design the more serious these are likely to be. The uncovering of some defects in a new aircraft is almost inevitable. However, the problems and difficulties are very much greater for the airline which is both sponsor and first operator.

airline costs of sponsoring new aircraft

The sponsoring and initial introduction into service of a new transport aircraft naturally involves extra expenditure to the operator concerned. This would not be incurred if the airline—like the great majority of operators throughout the world—were to purchase aircraft " off the shelf " which had already been developed and established in service by somebody else.

There are many difficulties in assessing the development and introduction costs of new aircraft. Mr. P. A. Wills, who was Technical Manager of B.E.A. in 1946-48, suggested (in an article in " Aeronautics " of February, 1950) that the adverse effect on B.E.A.'s financial results of introducing a major type (such as the Elizabethan) in the early 1950's would come to £1,890,000 spread over four years. Five years later, Mr. Wills showed (in " Aeronautics " of December, 1955) that B.E.A.'s financial results in the intervening years had provided some confirmation of this figure.

This 1950 figure of nearly £1,900,000 was based on the assumption that the Corporation would introduce one new major aircraft type every four years and includes the cost of the staff and organisation required to do this. A large element in this cost is that which results from the substitution every four years of new aircraft, operating at low initial utilisations and with low component lives, for established types which are operating at much higher intensities.

Costs have, of course, risen sharply since 1950. On the other hand, B.E.A. has been able, in practice, to build up the utilisation of its new aircraft rather more quickly than was originally expected. At the same time component lives—particularly the hours between overhauls of turbine engines—have increased more rapidly than was suggested by previous experience.

As a result of the interplay of these two factors and the increasing complexity of modern transport aircraft, it appears that the short-term adverse effect on B.E.A.'s financial results today of introducing one new major type every four years is of the order of £1,600,000 spread over the four years, or say £400,000 per annum. This short-term adverse effect is accepted by the Corporation as the penalty of operating new British aircraft. It is, of course, partly off-set in the longer-term by the improved economic results achieved by the new types, as compared with those which would have obtained if we continued indefinitely operating the older aircraft which they replace. There is, however, no doubt that B.E.A.'s overall financial results would be improved by something approaching the above figure if we did not concern ourselves with the task of new type introduction and, instead, bought American aeroplanes " off the shelf."

In practice, two further economic burdens associated with new aircraft introduction, beyond those which might have been expected with an " ideal " aircraft programme, have had to be borne by B.E.A. The first is that which results from bringing in two or more entirely new types simultaneously—as occurred, for example, when the Viscount and Elizabethan were introduced within a year of one another—and the second is when some additional type is bought

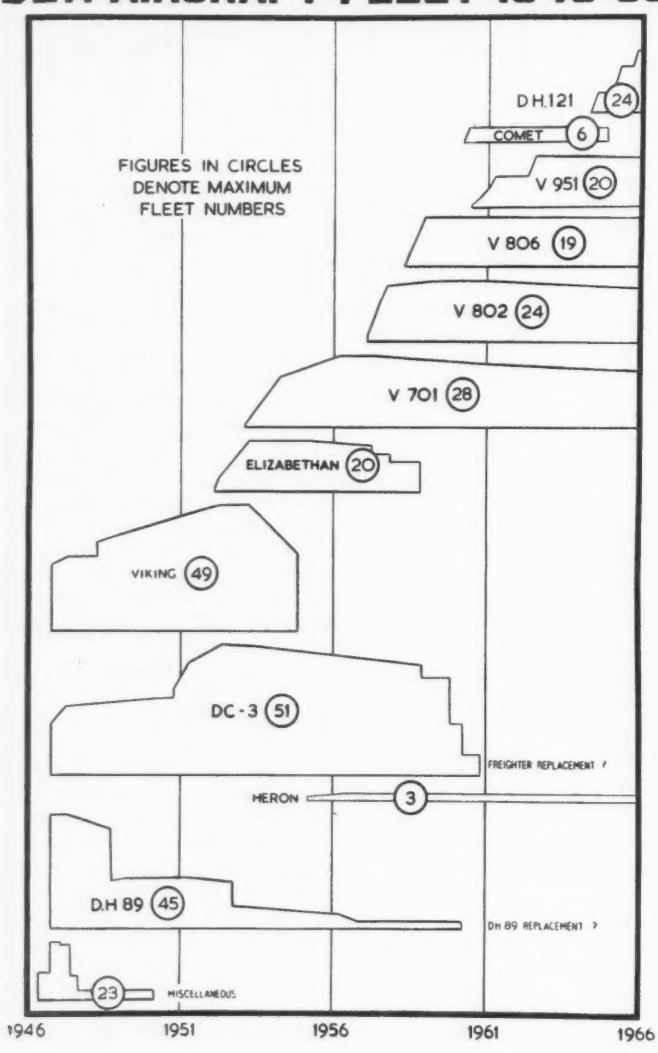


Fig. 6.

" off the shelf " to supplement the established aircraft programme for commercial or other reasons. Introduction of two new types almost together is undesirable, but occurred in the case of the Elizabethan and Viscount because of uncertainties in policy-making during B.E.A.'s formative years, resulting largely from doubts associated with the latter's use of turbo-prop engines. An example of the second type of order is that for six Comet 4B's which B.E.A. will bring into service early in 1960. These aeroplanes are not of a completely new type—being developments of the Comet 1 and Comet 4 of B.O.A.C.—but, even so, because the Comet 4B is a further development of the basic Comet design and has not been bought entirely " off the shelf," there is a considerable technical and operational burden associated with its introduction.

B.E.A. would have preferred to have introduced its own jet, the Airco D.H.121, into service in 1964 at a proper interval after the introduction of the turbo-prop Vanguard in 1960. However, the competitive situation which is clearly going to develop in Europe following the " jet buying spree " by airlines all over the world in 1956-58 forced B.E.A. to order a small number of Comets for service from 1960 as " interim jets " to supplement the Vanguards (Figure 6).

It appears that the addition of a further new type to the basic aircraft programme (which is working on its normal four-year cycle) adversely affects B.E.A.'s financial results by a further £500,000 spread over the life of the aircraft—with the Comet equivalent to £100,000 per annum. A completely " off the shelf " type should cost less than this, although how much less will depend on the degree to which the aircraft ordered differs from aircraft of the same type previously delivered to other operators.

In present circumstances, with B.E.A.'s planning and organisation geared to the introduction of the Vanguard and Comet almost simultaneously and of the D.H.121 four years later, the Corporations' financial results are probably being adversely affected by these new type introduction activities to the extent of about half a million pounds a year. The adverse effect will be rather greater than this amount during the first years of service of the new types (1960 and 1964) and will fall away to a rather lower figure in the years between.

conclusions

This Paper has stressed the contribution which " sponsoring airlines " make to transport aircraft development. This is because, from the operator's point of view, the importance of this contribution is the outstanding lesson of the post-war years. As one of the most active and successful airlines in the world

in this aspect of the business, B.E.A. is well-placed to gauge its importance and to assess its cost as well as its benefits to the operator. Our conclusions are that the financial burden on the airline is substantial and amounts, at the present time, to an average adverse effect on B.E.A.'s financial results of perhaps £500,000 per annum. In addition, the airline bears the risk of the new aircraft being unsuccessful, with all that this may imply in loss of revenue and prestige and nugatory expenditure. However, this contribution by the airline—and a parallel one by B.O.A.C.—is absolutely essential if the United Kingdom is to continue to manufacture transport aircraft.

In the wider context of the importance of the aircraft industry to the nation as a whole, there appear to be six main lessons which have been learnt in recent years and which must be applied in the future. These are that:—

(1) The Government will have to sponsor aeronautical research and development henceforth to a greater extent than will be justified by defence requirements alone.

(2) Transport aircraft manufacture is a particularly favourable field in which to apply the United Kingdom's highly developed scientific and technical facilities and skills. These are among our greatest national assets and they must be exploited if the best interests of the country are to be served.

(3) Government sponsorship will continue to be required for general aeronautical research and development, for promising new long-term projects (particularly supersonic and V.T.O.L. programmes) and—most important of all in the immediate future—to ensure the proper development and introduction into service of a balanced range of " bread-and-butter " transport aeroplanes.

(4) Specific—although probably relatively modest—Government financial assistance is required for those generally smaller categories of " bread-and-butter " transport aeroplane for which neither B.E.A. nor B.O.A.C. have a major requirement, but which have good export prospects. The assistance given may be required both to aid development and to ensure sponsorship and initial introduction into service by a United Kingdom airline. Government assistance may not always be required for the former but has become a necessity for the latter.

(5) British transport aircraft manufacture must be concentrated on fewer major types. A greater initial effort in ground testing and flight development is needed to eliminate faults before each type enters service. No manufacturer should undertake the development of more than one type of transport aeroplane at one time.

(6) Close liaison between manufacturer and the airline sponsoring a new type is almost essential to the successful development of a transport aeroplane. However, such association is not,

TABLE VI

THE WORLD'S PRODUCTION CIVIL TRANSPORTS

Category			British			Foreign		
			Aircraft type	Year of first service	Orders	Aircraft type	Year of first service	Orders
Mainline aircraft	Long-haul	jet	VC.10	1964	35	Boeing 707 DC-8	1958 1960	148 140
		turbo-prop	Britannia 310	1957	38			
	Medium-haul	jet	Comet 4 Comet 4B DH.121	1958 1960 1964	27 6 24	Boeing 720 CV-880 CV-600	1960 1959 1961	39 62 25
		turbo-prop	Britannia 100 Vanguard	1957 1960	15 40	Electra	1958	151
	Short-haul	jet				Caravelle	1959	50
		turbo-prop	Viscount	1953	406			
Feeder aircraft	Short-haul (turbo-prop)		Herald * Avro 748*	1960* 1961*	— —	Friendship	1958	148
Freighter aircraft	Short-haul (turbo-prop)		Argosy	1960	4			
	Long-haul (turbo-prop)		Britannic* Canadair CL-44*	1964* 1960*	—	Hercules*	1960*	—

* Offered, but not yet sold, to any civil operator.

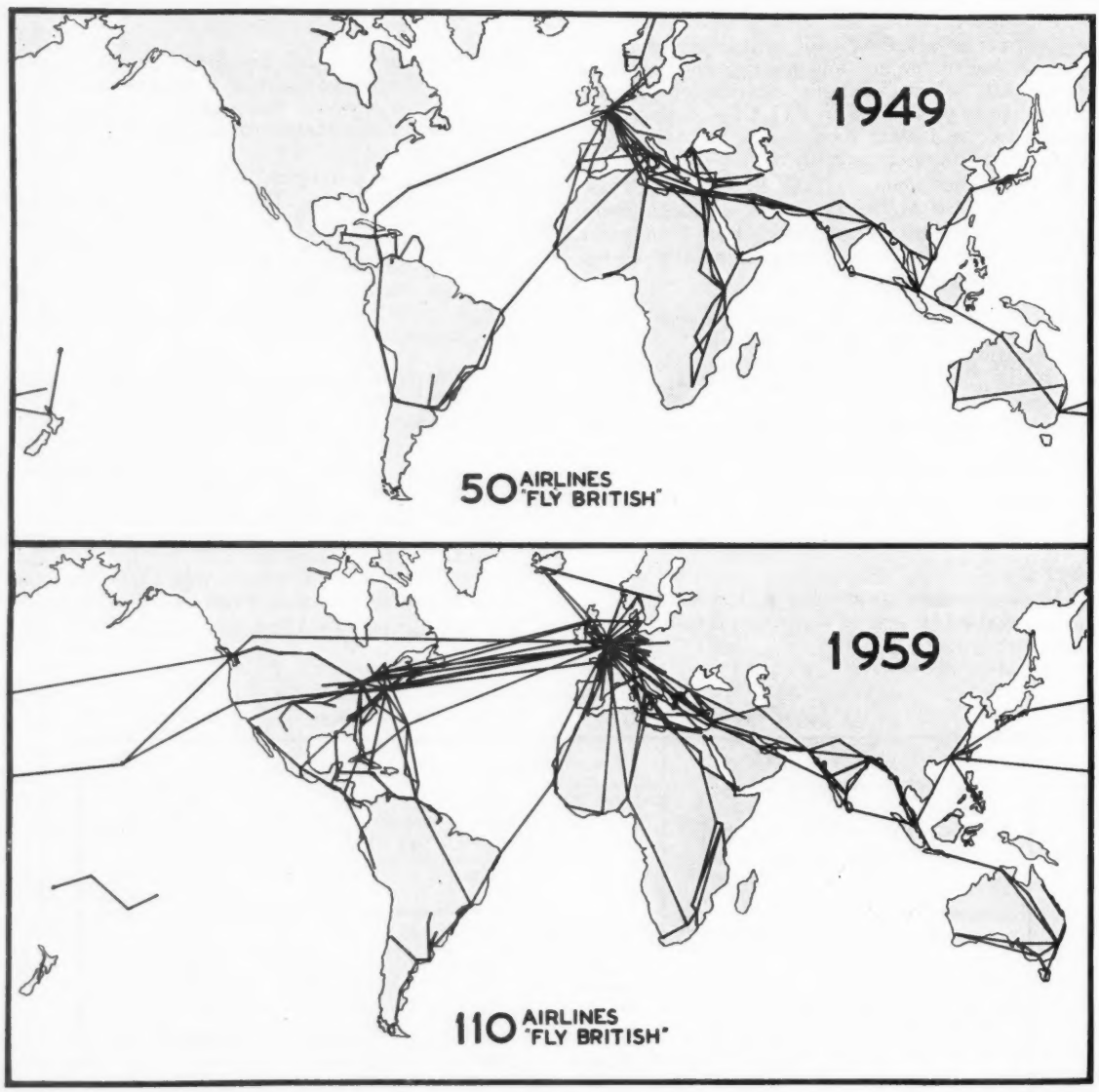


Fig. 7

of course, in any way an absolute guarantee of success. In the event of failure, the airline concerned is involved at least as much as the manufacturer and may sometimes suffer a great deal more in consequence.

In practical terms, the above conclusions add up to a need for this country to pursue with determination and without loss of confidence its established transport aircraft programme. The " bread-and-butter " types already in service or under development (Table VI) cover almost all the important categories in which the world's operating industry is interested. (Figure 7.) It may be, as the Table indicates, that some re-distribution of effort is desirable in one or two directions to reduce duplication and plug potentially

serious gaps, but there is nothing in the existing programme which realistic thinking and sensible policy-making cannot put right. In the light of development during the past two or three years, it is perhaps unfortunate that the British programme has placed so much emphasis on large turbo-prop types and that we are so late in the field in some of the jet categories. However, overall, the United Kingdom's position is not unsatisfactory provided the Government, and the manufacturing and operating industries, press forward together in the task to which they have jointly set their hands.

Experience since the War clearly indicates the vital importance of the " bread-and-butter " programme. If we can afford it, we must also undertake for the future research and development in preparation for the supersonic era and for certain other longer-term developments such as vertical take-off and landing. The proportion of our total resources to be devoted to these various future developments requires careful consideration. However, if we do undertake any long-term programmes, we must face the fact that they are going to cost a great deal and are only worth undertaking if, as a nation, we can afford to devote adequate resources to them. So far as finance is concerned, the distinction between such long-term projects and the " bread-and-butter " programme is fundamental. Much of the money for the latter has already been spent. All that is required to give some of the types, whose success is still uncertain, the opportunity which is open to them in the world's markets is relatively modest further financial help from the Government, perseverance by their manufacturers and support by the home operating industry. It may also be advisable to undertake from " scratch " the development of one further major type: a relatively small " Viscount Replacement " jet. If these steps are not taken, we will very likely squander our chances of further worthwhile returns on a prodigious 13-year investment in money, skill and faith.

acknowledgments

This Paper is the result of teamwork by a number of individuals in B.E.A. I would like to pay particular tribute to the work of Mr. Peter Brooks, who was mainly responsible for assembling and sifting the data. Valuable assistance in the preparation of the Paper was given by Mr. J. J. Scarlett. I am also indebted to Mr. Peter G. Masefield, Air Marshal Sir Charles Guest, Mr. B. S. Shenstone and Mr. S. F. Wheatcroft for reading and providing helpful comments on the original draft.

REPORT

In the Chair:
The Rt. Hon. the Earl of Halsbury,
F.R.I.C., F.Inst.P., M.I.Prod.E.

The **Chairman:** As President of the Institution, it is my pleasant duty to welcome all those who are not members of the Institution, or not members of the Southampton Section, to this Conference. I am sure that you would wish me to extend to the Chairman of the Southampton Section and to all his colleagues our congratulations on once more organising what has become a fixture in the aeronautical calendar. It is not so large an affair as the annual display at Farnborough, but it has become as regular an event. The number of very distinguished people attending proportional to the total number present, however, makes it just as distinguished a gathering as that central feature of the calendar.

We are opening this Conference with the Lord Sempill Paper, which is one of the short list of Named Papers of the Institution. It was named for Lord Sempill, a Past President, a distinguished engineer and one who has been associated with flying and the aircraft industry all his life, or at any rate for all his professional life. There is no rule of procedure by which we must assign the Lord Sempill Paper to this Conference, but it has become our habit to do so, and I am sure that it is a habit which will be welcome to Lord Sempill, who I am glad (to use a traditional phrase) to see in his place this afternoon.

This year we have selected, amongst the very distinguished participants in this Conference, Lord Douglas of Kirtleside to be the author of the Lord Sempill Paper. He is so well-known to you that he needs no introduction from me. At this point the speaker usually adds " nevertheless " and goes on to do what he has just said is unnecessary, but I am going to be as good as my word. Lord Douglas needs no introduction. We are exceedingly grateful to him for the very interesting Paper which he has written.

Lord Douglas :

The first thing that I want to do is to apologise for arriving late and keeping you waiting for your lunch. I attempted to get here in a helicopter, but at Basingstoke the cloud base was down to 200 ft. and so the pilot, rightly thinking discretion the better part of valour, brought the helicopter down in a field and we came on by car. That is why I am addressing you wearing my bedroom slippers and in rather a dishevelled state!

I am particularly pleased by the honour which the Institution has paid me by inviting me to deliver this fourth Lord Sempill Paper, chiefly, I think, because Lord Sempill is a very old friend of mine who started in aviation even before I did — and I have been

in it for 45 years. Lord Sempill first became connected with flying when he worked on the Gamma and Delta airships at Farnborough before the First World War, and since then he has played an important part in operational and technical progress in both the civil and the military fields. His contributions to the pioneering of domestic air transport and the development of the light aeroplane are particularly noteworthy.

My task today, however, is not to remember the past, pleasant though that is, but to address you on the subject of the aircraft industry as a national asset. I approach my subject from the point of view of one of the British Air Line Corporations which are required as a deliberate act of Government policy to Fly British and, in the process, to assist the United Kingdom aircraft manufacturing industry to develop transport aircraft which can be used both by home operators and by those in foreign countries.

I shall be careful, in considering this question, to avoid doing so purely from what might be considered a narrow air line operator's point of view. The Corporations do not have a free choice as between British and foreign equipment, and in my view it is right that this should be so; but this policy means that one of the Corporations' major preoccupations must be to do what they can to ensure that the British aircraft manufacturing industry produces the competitive equipment which it is essential that the Corporations should have, if they are to succeed in their primary objective of providing air transport profitably and at the least cost for the largest number of people. Only by succeeding in this main task can they play their main part in ensuring that the United Kingdom wins its proper share of the world's air carrier business and at the same time builds up a healthy aircraft export business.

(*Lord Douglas then presented the Paper which appears on pages* 289 - 303.)

The **Chairman:** I am sure it is your wish that I should express to Lord Douglas our most sincere thanks for the very interesting and highly informative Paper he has given us. I am particularly grateful to him because it seems to give me in a more compendious form than I have found anywhere else, a list of all the aircraft under development, their makers, and the numbers in service and on order.

This being a formal occasion we shall not have a discussion on the Paper, but Lord Douglas will be taking part in the general discussion tomorrow, and if anyone chooses to disguise a question on this Paper as part of that discussion, Lord Douglas may answer it.

There is one other thing which I would like to tell you. It is that this is the 50th anniversary of Lord Sempill's apprenticeship to Rolls-Royce, in the year 1909. (*Applause*). When I referred to him earlier I said he had been connected with aircraft all his life, and then I corrected myself and said all his professional life. Judging by his youthful appearance that correction may have been unnecessary; at any rate he must have been apprenticed at a very early age!

We thank Lord Douglas very much for his Paper, to which we have all listened with the greatest of interest. (*Applause*).

The Conference then adjourned for tea, after which the second Session was held.

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THE INDUSTRY'S POINT OF VIEW

by PETER G. MASEFIELD,

M.A., F.R.Ae.S., M.Inst.T., Hon.F.I.Ae.S., C.I.Mech.E.

Managing Director, Bristol Aircraft Ltd.;

President, Royal Aeronautical Society.

THIS afternoon we have heard a most interesting talk by Lord Douglas. Many of us would like to have a go at him in discussion, which may be possible tomorrow. Lord Douglas has pointed out that there is "nothing that he could not do if he had a few million pounds to spend", and we shall all echo that for our own sides of the business. He has referred to the problems which we face in this industry and said that they are highly complex and that the solution is not easy to distinguish. As I listened to him I recalled the words of Lewis Carroll :-

> "'Tis a pitiful tale', said the Chairman, whose face
> Had grown longer at every word,
> 'But now that he's stated the whole of his case
> More debate would be simply absurd'."

But whether absurd or not, my task is to attempt to present an industry view, and I take my theme not only from the theme of this Conference, but also from what Lord Douglas has said, that "the past successes of the United Kingdom in aircraft development have undoubtedly made an important contribution to our position as a world power". I think that the issue in front of us is this: "Can we manage to maintain that position in aeronautics in the decades ahead?" It is just about as simple as that.

The difficulty is to determine the way we should go.

You remember the Collect which enjoins us to pray that we may :-

> "both perceive and know what things we ought to do, and also may have grace and power faithfully to fulfil the same."

That is, I think, not a bad guide on how to focus our thoughts today. I should like to outline some ideas against that background.

In all we are doing today — whether in the field of military aeronautics, or in civil aviation — we have to remember that we are working in a highly competitive international business. It is no good ignoring commercially what is going on in other countries — as apparently, if I may be critical, the Government's "Supersonic Transport Aircraft Committee" has done. I shall have something to say about that later.

One of the most difficult aspects we face in British aviation today is the tremendous pressures on the speeding up of the rate of technical development, which are coming from both the United States and from Russia.

It rather reminds me of Lewis Carroll's "Mock Turtle's Song" which, you will remember, he sang "very slowly and sadly" :-

> "Will you walk a little faster?" said a (U.S.) whiting to a (U.K.) snail.
> "There's a (Russian) porpoise close behind us, and he's treading on my tail.
> "See how eagerly the (East German) lobsters and the (Chinese) turtles all advance!
> "They are waiting on the shingle — will you come and join the dance ?
> "Will you, won't you, will you, won't you — will you join the dance ?"

Today, "Will we, won't we, will we join the dance ?", whether supersonic or any other, is the great problem

Fig. 1.

Now, I am not going to read out my written Paper, on the theme of this Conference. A written Paper is to read. A "spoken lecture" is a different thing.

So, first of all — when we look towards the future — let us try to be clear about our objectives in a world which is, at once, internationally competitive, politically confused — about aviation at least — and, certainly, financially hazardous.

objectives of the aircraft industry

I believe that the broad objectives of our business in the aircraft industry can be set out thus :- They are —

to produce and to sell at a profit competitive types of aircraft with their spares and their equipment.

Now — these aircraft and their ancillaries must be :-

designed to meet and to develop growing demands in both the home and world markets.

If we can achieve that much, then we shall create :-

First — Stable Employment — in both the design field and in our production shops.

Second — A Steady Contribution to the national income (through the prosperity of our industry)

and we must not forget here that more than $1\frac{1}{4}$ million men, women and children in this country depend for their livelihood on the aircraft industry — and then :-

Thirdly — in the military field, a foundation for national security.

I might have added that — in the civil sphere — the contributions of our industry can help, materially, the success of our airlines, as well as provide a shop window for British goods, British skills and British techniques.

So much for our objectives.

If we can attain them, there can be no doubt that the theme of this Conference is right and that our industry is an important national asset which, I think, has served this country well in the past and can do even more in the future. As Lord Douglas has pointed out, we in the aircraft industry employ design and manufacturing skills which are of a high technological order, and we must try to preserve them if we are to continue to count as a world power.

We have, however, to face the fact that the big issue in front of us is — whether we like it or not — whether the aircraft industry in the United Kingdom can remain much longer in the "big league" of military and civil aeronautics, in a world in which research and development, in conjunction with design and production techniques, are being pressed forward to an extraordinary degree, under the influence of enormous defence expenditures in both the U.S.A. and in the U.S.S.R.

Looking ahead, I propose to divide my remarks under five headings: first, what we in this industry have achieved since the War; secondly, where do we stand today; thirdly, a word about supersonic transport aircraft, under which so much of our future problems can be summed up; fourthly, a word about how much it all costs; and lastly, a suggestion about the policy which we may require in the future.

First, what have we achieved? I think the employment situation shows the background here.

employment in the British aircraft industry 1935 - 59

From Fig. 1 it will be seen that fluctuations in employment in our industry are nothing new. Conditions in war-time, of course, are very different from anything that can happen in time of peace. What happened during the War could not happen in peace-time.

Fig. 2.

After a peak of nearly 1.8 million direct employees in 1943, the total numbers today stand at 244,000 men and women in direct employment. A downward trend began in 1957 and we must expect it to accelerate.

cmployment in the British aircraft industry 1946 - 59

Fig. 2 illustrates the past 13 years :-

First — the downward trend after the War ;

Then — the build-up during, and after, the Korean War;

Now — the results of the White Paper on Defence of April, 1957, and the increasing competition in air transport.

The figure shown for the present strength of the industry is 244,000 directly employed — which is 8% less than the 265,000 in January, 1957. We can add about 86,000 to this figure for the ancillary trades — including the repair business — making the present total some 330,000 (which is, I think, what Lord Douglas quoted). I believe that, as things are going today, the numbers of persons directly employed in the design and production of British aircraft, two years from now, may be some 100,000 less than today — that is about a 40% reduction.

It is a very serious state of affairs. We have to try to alter it.

I have not differentiated here between the engine side and the airframe side, and perhaps I ought to do so. The problems are not quite the same in each because the engine side can sell to foreign airframe builders. But that is the broad picture and we have to expect a reduction.

What have we achieved since the War?

One of the troubles about positive statements is that no precise, official figures are published for this industry, as is done regularly for the United States industry.

I would like to say to both the S.B.A.C. and the Ministry of Supply representatives present that I think this is a very short-sighted and unnecessarily restrictive policy. It leads to less than justice being done to a major British industry. The statistics for all the other major industries in this country are very detailed and complete, but this is not so for the aircraft industry.

Some estimates are possible however.

British aircraft industry estimated production since 1946

About 25,000 aircraft of 115 different types have been turned out in the United Kingdom since 1946. That means an average production run of about 220 aircraft for each type. In fact, such an average is very misleading. There have been a few big orders. The rest have been small.

It is interesting that the dozen types of which most have been made since the War have been :-

1. Gloster Meteors, more than 3,000.
2. de Havilland Vampires, more than 2,000.
3. Hawker Hunters, more than 1,500.
4. de Havilland Venoms, more than 1,000.
5. English Electric Canberras, about 1,000.

Then :-

6. Fairey Fireflies, nearly 1,000.
7. de Havilland Mosquitoes, more than 800.
8. Hawker Furies, more than 800.
9. de Havilland Chipmunks, more than 700.
10. Avro Ansons, more than 600.
11. Avro Lincolns, more than 500.
12. Military Austers, nearly 500.

So the first 12 types in production numbers are all military. The 14,179 aircraft covered by this list account for some 56% of the total output since the War. And they all come from five companies or groups — Hawker-Siddeley, de Havilland, English Electric, Fairey and Auster.

Indeed, 85% of the value of the aircraft produced since the War have been military. The total outlay has been some £3,500,000,000, including engines. The average cost works out at about £108,000 per aircraft. Another way of looking at it would be that each basic type set in hand has represented, with installed engines, an outlay of about £23,000,000 on design, development and production.

If we compare 1958 results with those of 1946 — in both years almost the same total numbers were employed — we see quite a change in the business.

British aircraft production — 1946 and 1958 (Fig. 3)

In 1946 the turnover amounted to some £90,000,000 for 2,700 aircraft, whereas in 1958 the turnover amounted to about £400,000,000 — some three-and-a-half times more including inflation, (or about twice as much excluding inflation) for some 800 aircraft plus guided missiles.

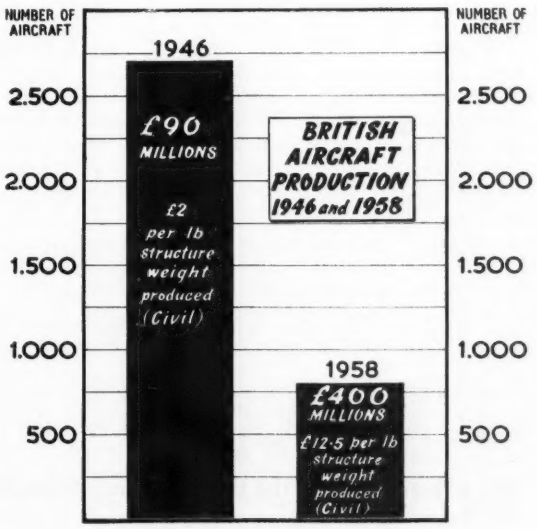

Fig. 3.

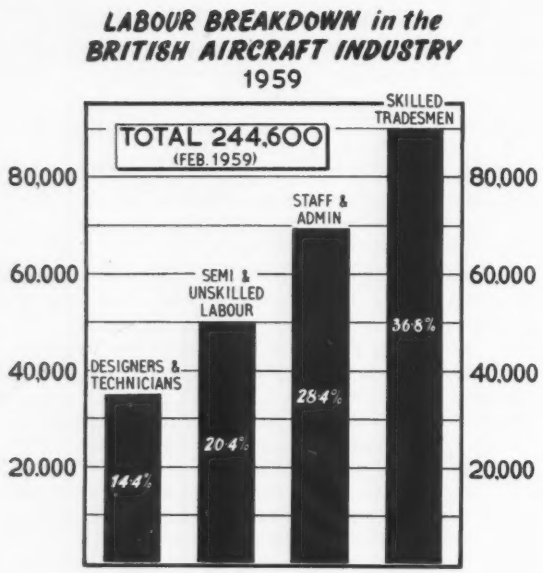

Fig. 4.

In 1946 about 87% of the output value were military, whereas in 1958 only about 66% were military.

Now, the figures quoted in the preprinted Paper are incorrect on these specific points. If anyone is writing them down — these are the correct figures — 2,700 aircraft in 1946; 800 aircraft in 1958, plus missiles. But the value in 1958 is three-and-a-half times more.

An interesting point, partly caused by inflation and partly by the increased complexity of aircraft types, is that whereas each pound weight of civil aircraft structure and equipment cost roughly £2 in 1946, the cost in 1958 was about £12.5.

The fact is that the complexity of aircraft design and fabrication has increased many times over in recent years. From an export point of view, the fact that each pound of structure weight now sells for an average of more than £12 sterling means tha. a high return is — and has to be — gained because of the skills required in the job. As Lord Douglas has said :-

> " Materials — expensive as they are (and growing more so) — indeed account for only some 15% of the cost of manufacture."

That is another very significant point, because it means that most of our expenditure is on skilled labour.

In fact, the total labour strength of the aircraft industry today is made up of some 51% of skilled tradesmen and technicians.

labour breakdown in the British aircraft industry 1959

As you see in Fig. 4, out of a total of 244,000 of people employed, some 90,000 (36.8%) are skilled tradesmen on the production floor and some 35,000 (14.3%) are designers, draughtsmen and technicians. Semi and unskilled labour accounts for a little over 50,000 and there are some 69,000 administrators, accountants, salesmen and other overheads — including those present this afternoon. We are perhaps rather too numerous.

The real difficulty, during the next few years, is going to be to maintain employment for the 90,000 skilled tradesmen.

Let us remember, too, that it is no good designing unless you produce, and sell, as well. Those teams have to be kept employed, and in balance.

That takes us to the export position. Lord Douglas has spoken of the achievement of the British aircraft industry in earning some £800,000,000 worth of foreign exchange since the War and achieving exports worth £160,000,000 in 1958.

U.K. exports, aircraft and spares 1958

In Fig. 5, this total has been made up of some £80,000,000 worth of military products and £80,000,000 worth of civil products in 1958. Of this latter figure, £40,000,000 worth represents Viscount sales and £12,000,000 worth Britannias. Comets are now coming into the picture again in 1959.

British aeronautical exports have, indeed, done especially well in dollar areas — thanks largely to the Viscount.

aeronautical exports

During the past year the chief countries to which aeronautical exports have been made are :-

1. India, £18,000,000 for aircraft and parts.
2. Canada, £14,000,000.
3. U.S.A., £13,000,000.
4. West Germany, £10,000,000.
5. South Africa, £3,200,000.
6. Australia, £3,000,000.

Indeed, when we look at United Kingdom exports to the United States we see that aeronautical products are high — in fact, fourth — on the list.

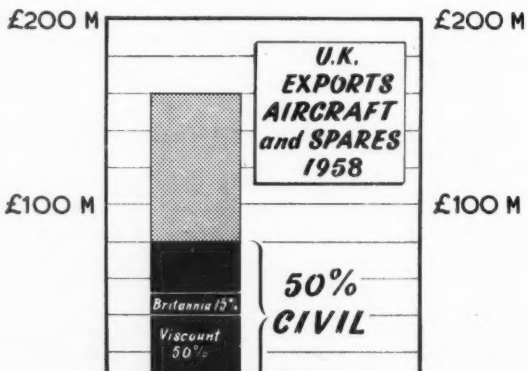

Fig. 5.

U.K. exports to the U.S.A.

In regard to exports to America, motor vehicles come first, with exports of £63,000,000 to the United States, and whisky second, with £32,000,000. The Americans have not managed to get a grip on this trade, as those who have drunk bourbon will realise. Machinery comes third, with £25,000,000, and aeronautical products fourth, with £19,000,000. Fifth comes manufactured metal goods with £16,000,000 and sixth woollen goods with £9,000,000. Again, the problem is whether or not we can maintain this position in the future.

Now can we maintain this position on exports ?

We have to face the fact that the value of military export sales, on which we have relied so much, is bound to decline with the gradual fading out of the manned military aircraft — although the sale of the Bristol Bloodhound Surface-to-Air Guided Weapon to Sweden is the first success in a wholly new field. Even so, the fact that manned military aircraft are on the decline, means that export sales of military products is bound to go down.

This puts greater importance on civil sales. And here we are slap up against the hottest possible competition from the U.S.A.

The problems are the relative sizes of the two industries, the depth of the United States home market and the progress the Americans are making in new civil types — especially jet aircraft.

U.K. and U.S. aircraft production — 1958

The United States output is some 10 times the British. Incidentally the figure of £500,000,000 for U.K. output in 1958 represents, airframes, engines and spares, and compares with the figure of £400,000,000 which I quoted earlier for aircraft and guided weapons only (Fig. 6).

We have to note also that, whereas nearly 90% of the United States output today is on the defence budget, less than 70% of the British output is military. We have indeed a formidable competitor there.

So, to sum up what we in the British aircraft industry have achieved since the War, we can say this :-

We have produced and sold some 25,000 aircraft, of which 85% by value have been military types. Military sales have amounted to about £3,000,000,000 —civil sales have added up to some £500,000,000, including aircraft, engines and spares.

In all, we have exported some £800,000,000 worth of aeronautical products — which is roughly 23% of the output. Military exports have added up to about £580,000,000 — which is some 16.6% of our output and also some 72.5% of our total aeronautical exports. Exports of civil aircraft and their equipment have added up to about £220,000,000. And out of that 36% was last year.

So far we have kept in direct employment more than 250,000 men and women — rather more than the important British ship-building industry and twice the numbers of the machine tool industry.

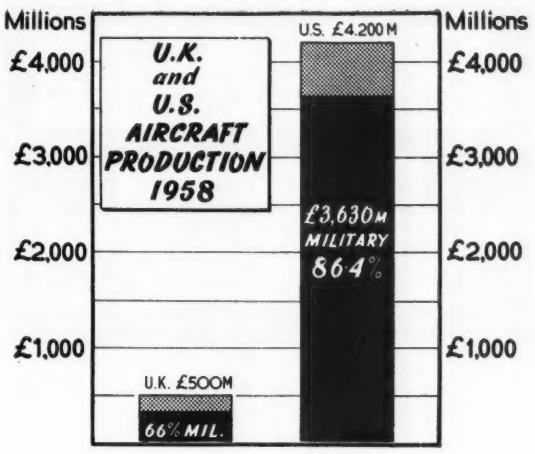

Fig. 6.

And we have, I believe, appreciably contributed to national security and that of the Western world as a whole.

That leads us to the present position. Where do we stand today?

There are, today, five basic types of aircraft.

five basic types of aircraft

First — Transport Aircraft. They may well be the most important in the future.

Second — Smaller types — say up to 20,000 lb. all-up-weight. This *can* be big business.

Third — Manned Aircraft for military operations. This is a declining commitment. But it used to be the lifeblood of this industry.

Fourth — Guided Weapons — a great technological problem.

Finally — Helicopters — a small but specialised business.

Those are the five directions in which we have to exercise our skills and our imagination. Those markets are intensely competitive and the aircraft are getting more and more complex and so, more and more expensive.

When we survey this field we find this :-

28 major types in production, 12 in design

We have 28 major types of aircraft in production and 12 major types in the early stages — a total of 40 types of aircraft (Fig. 7). But, of these 40, some 13 are nearing the end of their production runs. That means we have 27 active types of aircraft — and with aircraft I include guided missiles.

We have 17 major types of civil aircraft — but of them only five or six are likely to continue in sizeable production in the 1960's. At the present time the "backlog" of civil orders amounts to about £250,000,000 and 150 aircraft of eight types.

In more detail the 40 types can be set out as in Fig. 8.

28
MAJOR TYPES IN PRODUCTION
12
MAJOR TYPES IN DESIGN, PROTOTYPE OR PRE-PRODUCTION
23 MILITARY 17 CIVIL
UNFULFILLED CIVIL ORDERS IN THE BRITISH AIRCRAFT INDUSTRY
150 AIRCRAFT VALUED APPROXIMATELY £250M

Fig. 7.

MAJOR TYPES of BRITISH AIRCRAFT IN PRODUCTION and ON ORDER 1959-1960

R.A.F	NAVY	HELICOPTERS	GUIDED WEAPONS	CIVIL
ARGOSY AW660 BRITANNIA 253 GNAT JAVELIN Mk.8 JET PROVOST LIGHTNING VICTOR 2 VULCAN B2	GANNET NA 39 SEA VIXEN	BRISTOL 192 SKEETER Mk.12 WESSEX WHIRLWIND	BLACK KNIGHT BLOODHOUND BLUESTEEL BLUESTREAK FIREFLASH FIRESTREAK SEA SLUG THUNDERBIRD	ARGOSY AW650 BRITANNIA COMET HERALD TWIN PIONEER VANGUARD VISCOUNT
IN DESIGN, PROTOTYPE or PRE-PRODUCTION STAGES				
BRISTOL 188 BRITANNIC 3A TSR 2		ROTODYNE WIDGEON WESTMINSTER	SEA CAT	AVRO 748 BRISTOL 205 DH 121 VC 10

Fig. 8.

major types of British aircraft in production and on order — 1959 - 60

The names speak for themselves :-

11 R.A.F. types of aircraft;
3 fixed-wing types for the Navy;
7 types of helicopters — one for the R.A.F., one for the Army, two for the Navy, and three new civil types;
9 types of guided missiles — seven of them operational types;
11 types of civil aircraft — four of them in the design stage and only four in service.

Now, as you see, the bulk of the business is still on the Service side—the R.A.F., the Royal Navy and Guided Weapons. Yet this business is declining. We have to lean much more heavily on the civil side. And this is where we face the stiffest competition from the United States.

Now, a major difficulty here is that, whereas British civil aircraft have to stand on their own feet, United States civil types have owed an enormous amount to the United States Armed Forces.

civil and military orders and sales of transports

In Fig. 9 you see — above the line — United States and British sales of civil aircraft and — below the line — the military sales of the same basic types.

In the United States there were 2,646 civil aircraft built of nine basic types. And there were 2,972 military aircraft built as military transport or tanker versions of these same types.

In the United Kingdom there were 569 civil aircraft built of six basic types, and there were 51 military aircraft built as military transport versions of three of those types. What a difference!

CIVIL and MILITARY ORDERS and SALES of TRANSPORTS

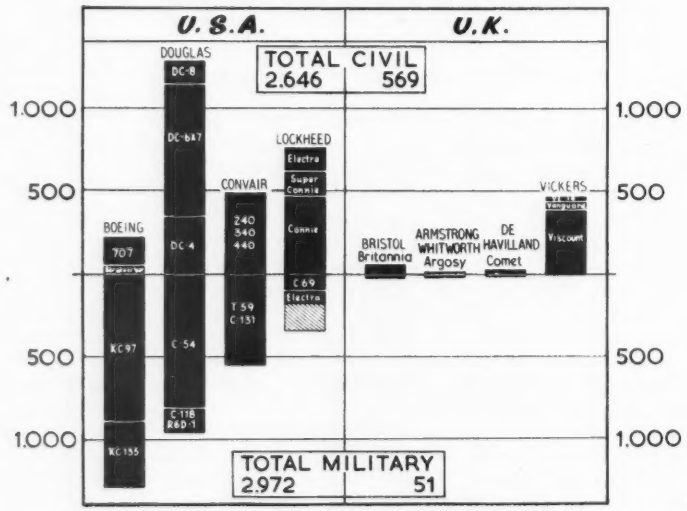

Fig. 9.

To take just one example — Boeing: 888 KC-97 Stratotankers were built — and 56 civil Stratocruisers. The types are structurally identical. All the jigs and tools and development flying were paid for out of the Service contract.

402 KC-135 jet tankers have been ordered. Civil sales of the identical Boeing 707 have reached 164— that is 40% of the military order.

Now look at the British side of the slate. Maybe our requirements are different. But it certainly makes it tough going in the civil field. The two largest producers of *civil aircraft* in the world are Douglas and Boeing.

percentage of civil and military orders

As you see in Fig. 10, 79% of Douglas orders are military — an annual turnover of $1,000,000,000 on military work. That figure, which includes missiles, is likely to be bigger in 1959.

Boeing are rather worse off, with only 75% of military orders. But these two are the largest builders of civil aircraft in the world. When we look at their production lines and see these aircraft of over 300,000 lb. coming off at the rate of about one a day, and consider that the structures of the KC-135 and Boeing 707 are identical, we realise the problems with which we are faced in the civil field. I do not think that we should be downhearted, but we have to recognise that these long production lines give, in jigging and tooling and so on, a tremendous advantage to our American friends.

So, in this pattern, we in this country still have to look to civil aircraft as bringing us a lot of our "bread and butter" in the future — civil aircraft and guided weapons will have to be our staple aeronautical output. And we have to face up to American competition.

This may usefully lead us to an examination of the "spectrum" of aircraft types and sizes which are being produced here and, competitively, in the U.S.A.

The odd thing here (Fig. 11) — when we plot total gross weight in tons against groups of sizes of aircraft — is that there is a gap in both military and civil types in the 50,000 - 100,000 lb. classes. Nor have we any heavy bombers.

When we look at the comparable American pattern (Fig. 12) to a vertical scale which is three-and-a-half times that of Fig. 11 — we see that the Americans have a lot of small aeroplanes and a lot of very big aeroplanes. But again there is the gap between 50,000 - 100,000 lb.

This is, in fact, the area of what one might call a Viscount/Convair Replacement.

Head-on competition between new British and American aircraft in similar categories, for the limited civil market, does not seem to be sensible. As yet there is no American competitor in this field.

Here may be a golden opportunity.

But, before we leave this comparison of the British and the American scenes, an interesting thing is to analyse the comparative sizes and costs of the British and American transport aircraft on order — incidentally the British back-log of civil orders

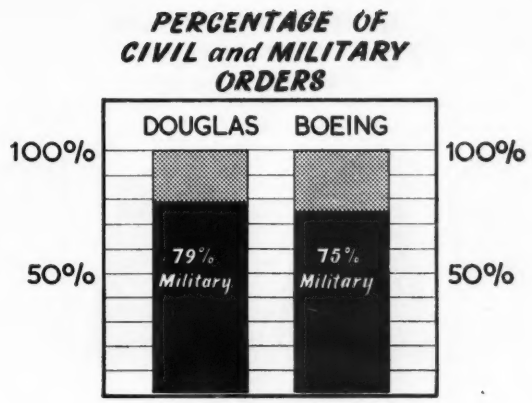

Fig. 10.

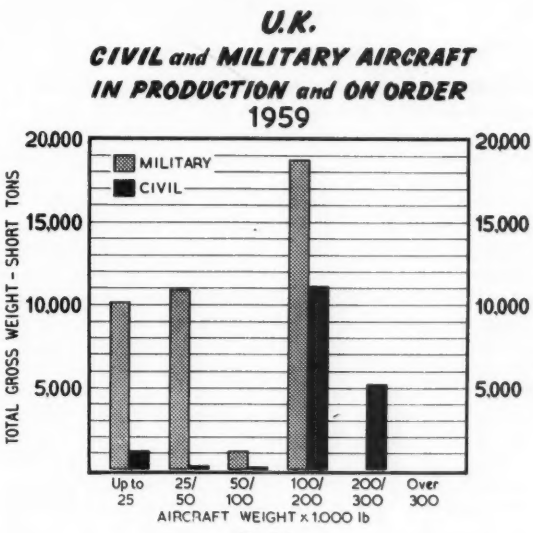

Fig. 11.

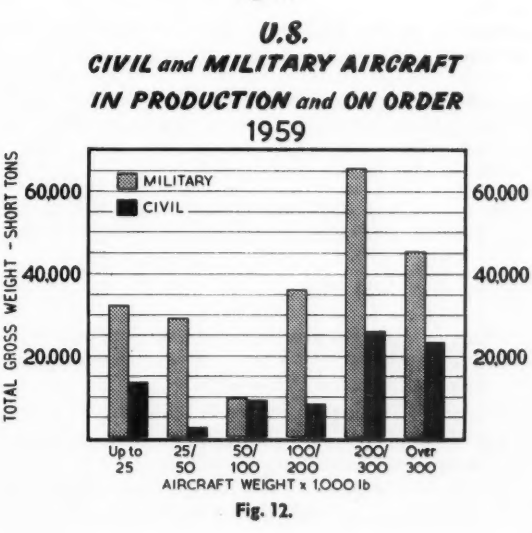

Fig. 12.

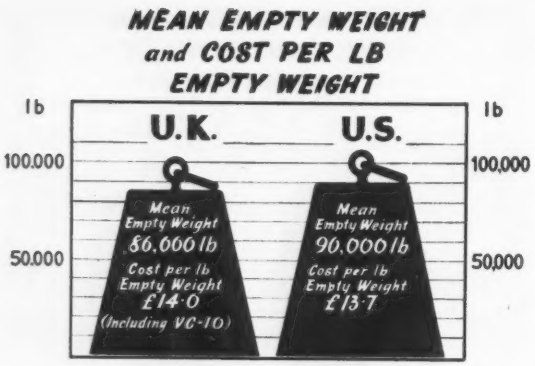

Fig. 13.

amounts to £250,000,000, the American back-log to £1,000,000,000 (Fig. 13).

The comparative specific figures are, however, surprisingly similar. These are for civil transport aircraft on order.

When we include the very large VC-10, the British figure is 86,000 lb. — the American figure 90,000 lb. And the British cost £14 per lb. of empty weight — the Americans with their big production runs, (but in spite of their much higher labour costs) come out less — at £13.7 per lb.

fly British

I want now to turn to a different aspect and to follow up another of Lord Douglas' points.

If we are to see prosperity in the British aircraft industry in the days and years ahead, we must expect that overseas sales of British transport aircraft will be founded on a "Fly British" policy in the home market.

Such a policy has been stated categorically by successive Governments on a number of occasions.

There are indeed powerful national advantages in such a policy — provided, of course, that fully competitive British aircraft are produced to make it possible.

The national advantages are :-

First — That the large capital sums needed for aircraft and spares are spent in a home market — so that :

Second — Employment is maintained in a skilled industry.

Third — Exports are developed on the basis of a healthy home market — and expenditure of foreign currency is avoided.

Fourth — National prestige is built up.

Fifth — There is an indirect benefit to national defence; and

Finally — This is, anyway, the only means of developing new British transport aircraft.

These advantages are so important that, in the national interest, the most strenuous efforts must obviously be made to meet the basic requirements of competitive and economic aircraft produced at the right dates.

Now this "Fly British" policy has — as I have said — been recognised and stated by every successive Government for the past 20 years.

You may remember that, in 1938, the Cadman Committee recommended that — I quote :-

> *"State assistance should be given to encourage the production of suitable types of air liners."*

And that the British operating companies :-

> *"should be given special grants to keep their fleet equipped with new British aircraft."*

and that :-

> *"A programme of development for large aircraft for Empire and other long distance routes, should be formulated."*

That was in 1938.

The Government of the day accepted these recommendations and added — I quote :-

> *"The dual policy of direct development expenditure and of encouragement through the subsidised operating companies will be steadily pursued in future years."*

Unfortunately the War intervened.

I think that our present Government might be reminded of that fact.

After the War, however, the same policy was restated in Government White Papers.

In March 1945, Lord Swinton presented a White Paper which said :-

> *"It is, of course, the intention of H.M. Government — as it is the desire of the Corporations — that the Corporations should use British aircraft."*

In December 1945, Lord Winster — the succeeding Minister of Civil Aviation — in another White Paper, said :-

> *"It will be the general policy of H.M. Government to require the Corporations to use British aircraft. H.M. Government are taking all possible steps to accelerate the production of civil aircraft — both for the equipment of British airlines and for the export trade."*

In the event B.E.A. has pursued this policy steadfastly. B.E.A. has, in fact, never bought a new aeroplane which was not built in the United Kingdom — except, I regret to see, the helicopter Lord Douglas came in today.

Unfortunately the same cannot be said of B.O.A.C. Through a number of circumstances, mechanical and human, only about one-third of B.O.A.C.'s services since the War have been operated by British equipment.

That is in the past. The critical issue is what happens in the years ahead?

And of course, an awful lot depends on what aircraft can be designed and produced.

Not everyone realises that the responsibility for achieving successful new aircraft begins some six years before the aircraft are required in service. It is a responsibility which has to be shared equally between the manufacturer and the operator.

The manufacturer has to state — with foresight — what is *just* possible six years ahead — and then achieve it. The operator has to specify, in time, what he wants and from whom he wants it — and when.

In fact, all the world's most successful transport aircraft have been achieved as a result of a close operator/manufacturer liaison from the start.

For instance :-

The Short Empire Boats of 1936 came from Imperial Airways/Shorts partnership.

The Douglas DC-2 and DC-3 of 1934-36 came from T.W.A./Douglas partnership.

The Lockheed Constellation of 1939-40 came from T.W.A./Lockheed partnership.

The Boeing Stratocruiser of 1945-46 came from United/Boeing partnership.

The Vickers Viscount of 1949-50 came from B.E.A./Vickers partnership.

Now the problem ahead can be divided into two parts :-

1. An order from a British Corporation — or from R.A.F. Transport Command — is essential to a decision to start a major new British transport aeroplane — because no foreign operator is willing to buy a British passenger aeroplane which has not been adopted for the home market.

But, nevertheless, the order from a British Corporation is not likely to be for sufficient numbers to make possible a break-even on a production run. That is the first point.

2. How do we achieve the output of a new British civil aircraft for which there may well be a world demand, if the type is not required —at the right time — by either B.E.A. or B.O.A.C.? Somehow we have to achieve these things.

To quote again from "The Hunting of the Snark" :-

"The thing *can* be done" — said the Butcher — "I think,
"The thing *must* be done — I am sure,
"The thing *shall* be done — Bring me paper and ink
"The best there is time to procure."

This thing has to be done in the task of the policy formation which lies ahead.

This latter point is, I am sure, a burning issue on which a forward national policy is needed today.

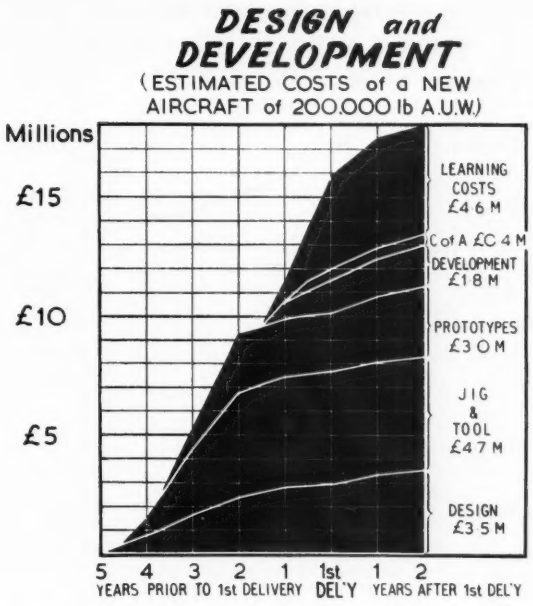
DESIGN and DEVELOPMENT
(ESTIMATED COSTS of a NEW AIRCRAFT of 200,000 lb A.U.W.)
Millions
£15
£10
£5
LEARNING COSTS £4 6 M
C of A £C 4 M
DEVELOPMENT £1 8 M
PROTOTYPES £3 0 M
JIG & TOOL £4 7 M
DESIGN £3 5 M
5 4 3 2 1 1st 1 2
YEARS PRIOR TO 1st DELIVERY DEL'Y YEARS AFTER 1st DEL'Y

Fig. 14.

The problems are made a little clearer, I think, if we glance at the costs involved.

Let us take, for example, a large, new, subsonic jet transport aeroplane of, say, 200,000 lb. loaded weight (Fig. 14).

Here is an approximate breakdown of costs of design development and initial production.

You will see that, up to the time at which production can begin, a total of £12,000,000 is involved. For that we have two prototypes brought up to C. of A. standards.

These costs, incidentally, include a figure for escalation so that a fixed price contract could be quoted.

When we start production we have to add the "high initial batch costs" whereby the learning curve adds to the cost of early production aircraft.

In other words, total preparatory costs, for an aeroplane of the size, may well add up to more than £16,000,000 — including jigging and tooling and high initial batch costs.

It means, in fact, that — to break-even over 100 production aircraft of this size — we have to sell at about £1,200,000—or £13.4 per lb. of empty weight, which is just about the top level which the market will bear, that is, if fares are to remain at present levels.

In fact, to make anything like a reasonable profit — when finance charges are taken into account — one would have to look for the sale of not less than 200 aircraft. Quite a tall order!

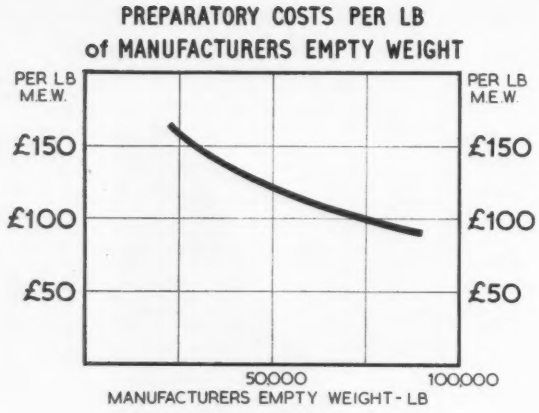

Fig. 15.

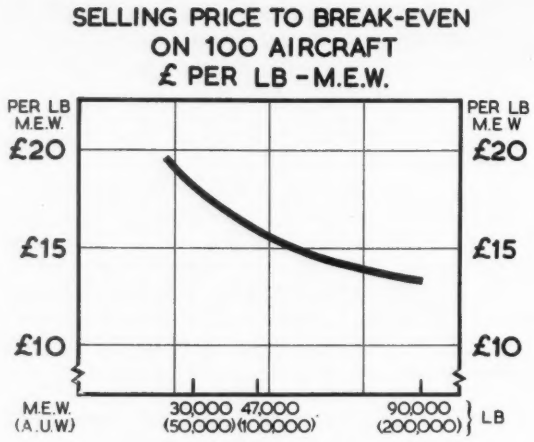

Fig. 16.

If we look now at the "spectrum" of sizes of aircraft we can see that the "pre-production or preparatory costs" of a range of aircraft from 50,000 lb. A.U.W. to 200,000 lb. A.U.W. work out on a curve (Fig. 15).

The costs, which include jigging and tooling but no production, range from £150 per lb. for a smaller aeroplane down to £90 per lb of manufacturer's empty weight, assuming, of course, equal complexities (which may not be quite fair on the small aeroplane).

These are costs before production begins. But they do include tooling for production. They are formidable figures. They add up, in fact, to preparatory costs of :-

£9,000,000 for a 50,000 lb. aeroplane;
£12,000,000 for a 100,000 lb. aeroplane;
£16,500,000 for a 200,000 lb. aeroplane.

When we come to sell the aircraft, if we set a break-even point at 100 aircraft, then this is what comes out (Fig. 16).

You see that the cost per lb. of manufacturer's empty weight ranges from about £18 to £13 according to size. The bigger the aeroplane, the more you get for your money, assuming equal complexities.

It means, in fact, a selling price of :-

about £550,000 for a 50,000 lb. aeroplane;
about £750,000 for a 100,000 lb. aeroplane;
about £1,200,000 for a 200,000 lb. aeroplane;

all of equal complexity and equipment.

As a commentary on both inflation and complexity :-

The Blenheim of 1938 cost £0.46 per lb. of A.U.W.
The Bristol Freighter of 1945 cost £1.00 per lb. of A.U.W.; and
The Britannia of 1956 cost £6.1 per lb. of A.U.W.

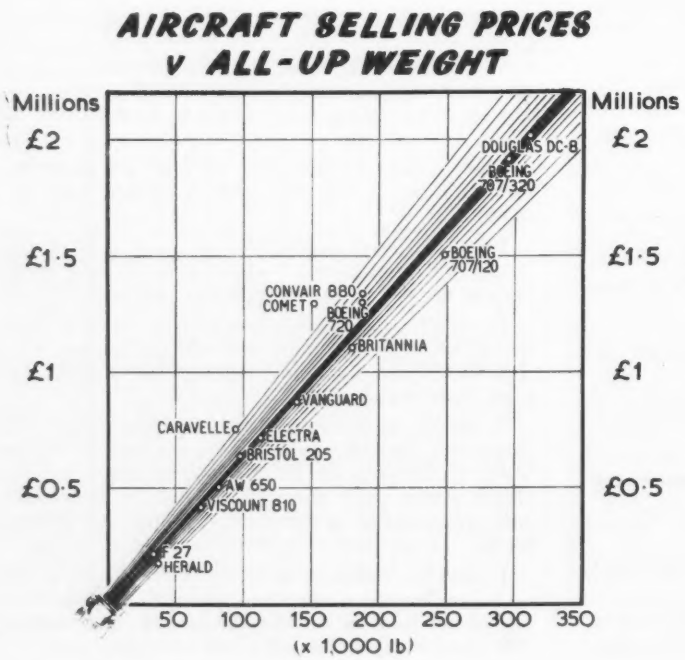

Fig. 17.

When we look at what is being sold, we see (Fig. 17) that the 200,000 lb. gross weight aeroplane costs about £1,250,000 and the 300,000 lb. big new jet nearly £2,000,000.

" searchlight beam " of selling prices

For £500,000 you can expect to get about 75,000 lb. of all-up-weight of aeroplane.

Oh, for the good old days when a " giant airliner " weighed 25,000 lb. and cost £25,000 !

These present-day sums are very large. The risks are great. The profits are small. " You don't have to be crazy to be in aviation — but it certainly helps."

The question is : *" Can the British aircraft industry hope to survive, economically, on such a basis of predominantly civil orders — unless Government support is forthcoming ? "*

I do not make a great cry that we cannot manage without Government help. But I think that our business will be small when we have to compete with the Americans, and perhaps later with the Russians, if there is not a national policy on this subject. What we must have is, I think, quite clear.

It is a *concise and comprehensive Government policy towards research and development and the procurement of new British transport aircraft.*

We have to survey the field, decide what we can do technically, what we can afford to do — and then get on with it.

And it's certainly true that no company in this industry can afford to " go it alone " on a major new civil project — any more than a new major Atlantic liner can be built entirely privately today.

The question is simply : *" Do we stay in the ' Big League ' of transport aircraft manufacture — or do we not ? "*

That leads us directly to the burning " question-of-the-hour " — the Supersonic Transport.

As we all know, a Committee made up of representatives from the Ministry of Supply, from five British aircraft manufacturers (including my own company), from B.E.A. and B.O.A.C., the Air Registration Board, the National Physical Laboratory and from the Ministry of Transport and Civil Aviation — under the Chairmanship of the Royal Aircraft Establishment — has been sitting for some months on the problem of the supersonic transport aeroplane.

It has recently reported.

The Ministry of Supply has said that this Committee has recommended that further studies should be made leading to two types of aircraft :-

(i) A 100-passenger aeroplane cruising at M-1.2 (800 m.p.h.) for 1,500 miles.

(ii) A 150-passenger aeroplane cruising at M-1.8 (1,200 m.p.h.) for the London-to-New York operation.

The Committee has suggested that the development costs would be a little under £100,000,000, but I have little doubt that this is an underestimate.

What these aeroplanes would look like is still to be determined.

Bealine buzz

Fig. 18 is a drawing which I had done in my B.E.A. days five years ago — it may not be far out.

The reasons why those relatively low supersonic speeds — 1.2 and 1.8 — have been proposed are said to be :-

(a) because the technical problems are likely to be less difficult.

(b) because the operating economics may be less critical; and

(c) because existing research and development would make possible such a limited step forward with some confidence of success.

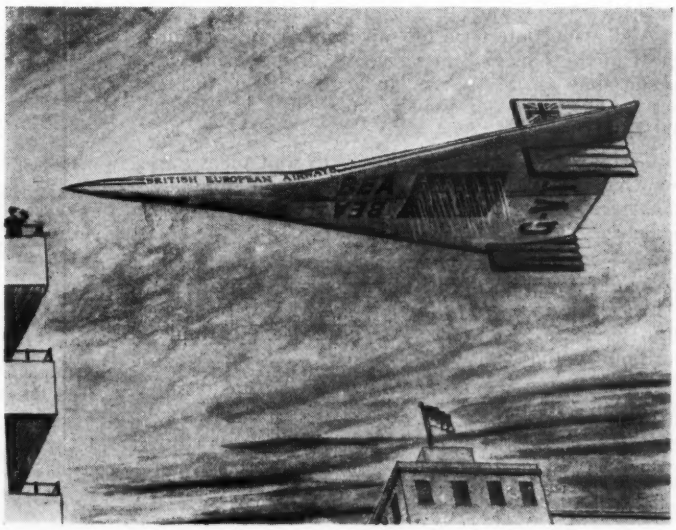

Fig. 18.

Fig. 19.

I must say that although the recommendations of the Committee would obviously make sense in a non-competitive world, the fact is that, in my opinion, they make commercial nonsense when we must expect the United States — and even Russia — to be pressing forward with much more advanced aircraft, and to succeed. It would be ridiculous to take the view that they have bitten off more than they can chew.

The fact is that the Convair B-58 bomber in the United States is already flying at M-2 for extended periods. The North American B-70 bomber, which is to fly next year, will be cruising at M-3 — that is 2,000 miles an hour.

And at a conference on supersonic transport aircraft in the United States recently, a statement was made that an M-3 aeroplane could be in airline service by 1970 — cruising at 2,000 miles an hour at 80,000 feet.

Certainly it is commercial folly to shut one's eyes to what is going on elsewhere, or to underestimate what the United States or the U.S.S.R. are likely to achieve.

We may well ask ourselves "would B.O.A.C. be prepared to order a British aeroplane cruising at 1,200 miles an hour (M-1.8) if P.A.A. was bringing into service a M-3 transport cruising at 2,000 miles an hour at the same time-?".

There is another point one has to take into account.

When we plot the block times from airport to airport for aircraft cruising at different speeds for particular ranges, we come on a very interesting thing.

London/New York operation — speeds and times

You will see in Fig. 19 that whereas a M-1.8 aeroplane takes $3\frac{1}{2}$ hours between London and New York, a M-3 aeroplane will cut the time to a little under $2\frac{1}{2}$ hours. This is a significant competitive advantage. On the other hand, once we achieve M-5 — which is not at all impossible — there is very little to be gained from any further increase in speed on this particular route.

What this suggests therefore is that M-3 is certainly worth going for, commercially, and that such a speed would have a significant advantage over M-2. However, after M-3 there is very little more to be gained by further increases in speed for this range.

There is yet a further point, however. There seems no doubt that a M-3 transport would cost not less than £150,000,000 to the pre-production stage, and that the market would be very limited even after a C. of A. had been gained.

Certainly one could not reckon for a sale of more than about a dozen aircraft with any confidence, considering the amount of work which each would do. Ten 200-passenger aeroplane cruising at M-3 would carry in a year all the passengers now flying the Atlantic on all airlines.

We would probably find, therefore, that we would have to spend somewhere around £300,000,000 to get 10 production aircraft, which would work out at £30,000,000 each. On this basis their economics would look appalling. The cost per seat mile would be many times those of present-day aircraft.

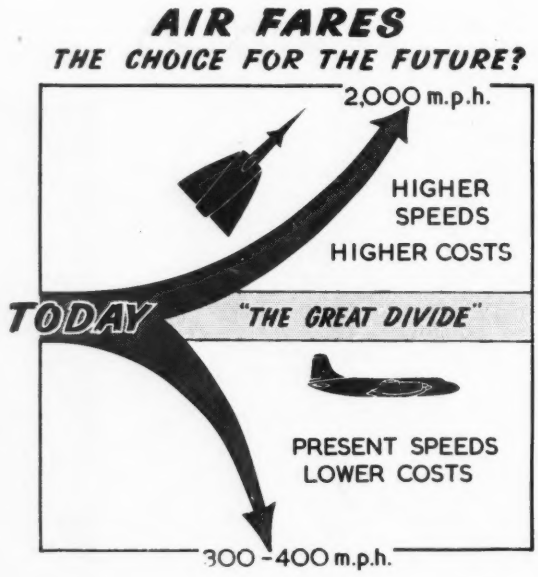

Fig. 20.

Even if the development costs were written-off and not charged against the aircraft, their economics are still likely to look bad.

There seems to me very little possibility of producing competitive and economic supersonic aircraft unless they are based upon a military programme — as certainly they will be in the United States.

Some facile talk of supersonic economics reminds me of the Beaver's problem in "The Hunting of the Snark":-

"It felt that, in spite of all possible pains,
"It had somehow contrived to lose count,
"And the only thing now, was to rack its poor brains
"And reckon up the amount."

And some amount it will be.

We, therefore, come up against the problem of whether it makes any sense for this country to go in for supersonic transport aircraft anyway. There are so many complex issues concerning national prestige as well as detailed technical possibilities, and the whole economic background, that I believe it can be settled only on the most searching examination by a really qualified Brabazon/Cadman-type Committee which would have to take into account many other things as well over the whole field of British aeronautics.

I hesitate to recommend another committee, but I believe that it is necessary in this case. It would have to survey the whole field of British aeronautics and the contemplated spending of £300,000,000 and decide whether or not that would mean going in the right direction.

One of the great conundrums for the future is where air fares should go.

In my view tremendous markets await lower fares, and I feel certain that the pressure for higher speeds will inevitably bring higher costs. At the same time, if we can be content with present speeds we could see startling reductions in costs were we to set our mind to that task (Fig. 20).

In other words we may now be reaching "The Great Divide" — higher speeds with higher costs and present speeds at steadily lower costs, with a differential between the two. People with expense accounts on one side and we and our families on the other. This is a further serious issue for our industry. I have little doubt that the really big business is in the lower cost market.

The Americans are going into the supersonic business and so obviously what we must do is to study:-

(a) Do we go into supersonics at all in view of the high cost, the hot competition and the limited production?

(b) If we do enter the supersonic lists, what speed should we choose?

In the longer term, possibly the techniques being gained with guided missiles may lead to a simpler solution to supersonic flight than with a more conventional type of aeroplane.

It is interesting to analyse the speeds required to cover various distances up to the maximum terrestial journeys we need, namely, from London to Melbourne, 11,000 miles.

As Fig. 21 shows, if we take the North Atlantic range, 3,500 miles, we can never hope to cover it in much less than two hours, whatever speeds we fly.

For a two hour flight, block to block, we need a Mach number of 5 — that is 3,300 miles an hour.

We can never do the North Atlantic range in an hour, because of the terminal times, but we can do it in two hours at M-5. We see from these curves that we shall never bring the time under 2 hours at whatever speeds we go, so that for the North Atlantic M-5 is the maximum we need consider.

At the other end of the scale we can never hope to get to Melbourne, Australia, half-way round the world, so it does not matter which way we go — in anything less than 2½ hours, and to achieve that we need to fly at M-13 — that is 8,500 miles an hour.

One may remark that the present foreseeable limit is about M-8, at which speed the skin of the aeroplane will be approximately at the same temperature as that of turbine blades in jet engines today. As that is about the limit of our metallurgical knowledge, that is probably as fast as we shall be able to contemplate in the present state of the art.

If we limit ourselves to M-8 we would be able to cover some 7,500 miles in 2½ hours — just time for a decent meal.

The problem is best seen in the analysis of the flight envelope (Figs. 22 and 23).

If we plot speed against height, up to 500 m.p.h. and 50,000 feet, the turbo-jet is shown in the fashion indicated, and we have to go up the "corridor". Going beyond that, we have in Fig. 23 the flight corridor between "too hot" and "too slow". We are struggling today at the bottom corner, and we shall have people flying along this corridor one day. But at what cost?

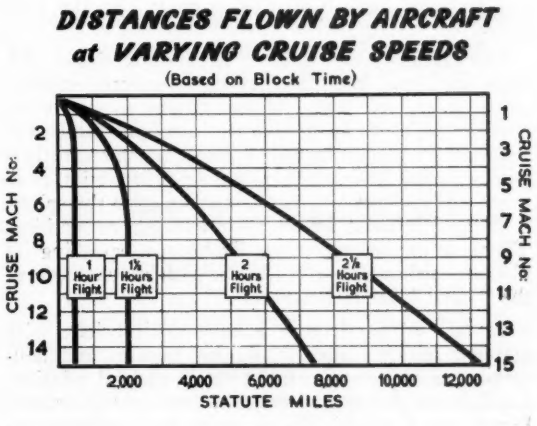

Fig. 21.

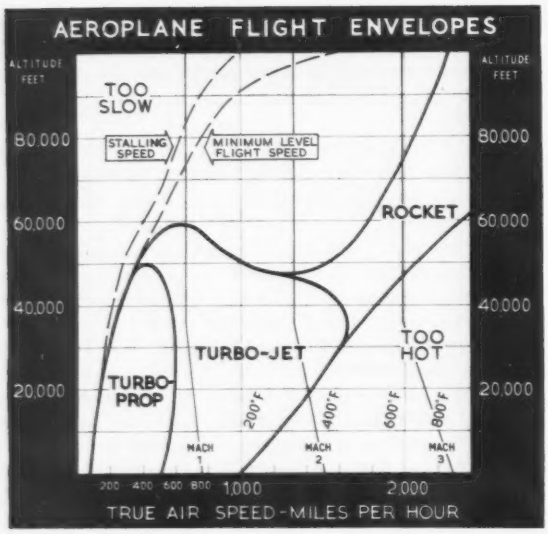

Fig. 22.

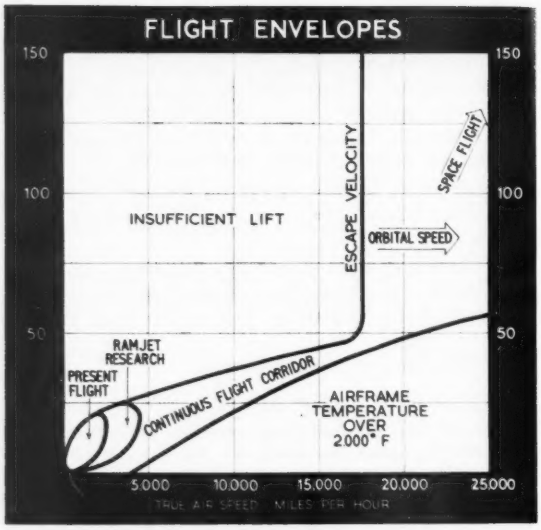

Fig. 23.

There is another aspect of the question—passenger reactions. It may perhaps be represented by a cartoon in the *New Yorker* of someone saying to the travel agent: "We have waited 25 years to make this trip, and we are not interested in getting there in only 6½ hours".

So much for the supersonics.

My own feeling is that in the present state of our knowledge the £300,000,000 or so involved might well be better spent in British aeronautics, unless we could work out some collaborative arrangement with the United States whereby the heavy development cost is shared and a reasonable production rate is assured.

But it needs the most serious further examination by a widely representative body.

I feel that only from such a study can the path ahead be determined with force and logic.

One thing is quite clear. It is useless to tinker with these problems. We must get on, in selected spheres, or we must get out. If we decide to undertake specific tasks we must allocate adequate funds and research and manufacturing effort to them. Otherwise we must leave them alone. In aeronautics, as in any technical task worth attempting, once the sphere is defined it must be an all-out effort, or nothing. There must be no more Brabazons, speaking of aircraft, although we could do with much more of the "Lord". He is, however, unique.

In my written lecture I have dealt briefly with manned military aircraft, guided missiles and helicopters, as well as one other branch, general aviation. I will leave the rest of these matters to my written Paper, but I would like to make one comment on general aviation.

U.S. civil aviation 1958

The tremendous increase in what the Americans call general aviation — small aircraft doing all the odd jobs other than commercial services — is one of the extraordinary things about aviation in the United States today (Fig. 24).

There are 96,000 general aviation aeroplanes on the United States register. They flew 11,000,000 hours last year and covered 1,400,000,000 aircraft miles. No less than 6,400 aeroplanes were built to a value of $135,000,000, which is about £7,500 each.

We have not that depth of market in this country, but I think we have a sizeable market in the Commonwealth, where the Americans sell a lot of these small aeroplanes. I believe that there is a big market for British aeroplanes there, and I hope that we shall recognise it and do something about it. It is a challenge to our industry when we see the size of this business in the United States.

the civil aircraft situation

So much for civil aviation, on which this industry must depend so much in the future.

We may perhaps sum up the transport aircraft situation in this way. There are today a total of 5,200 civil airliners in service with commercial air carriers of the Western world (Fig. 25). They will have to be replaced at a rate of some 250 aircraft a year, allowing for the expansion of the business and the fact that larger and faster replacement aircraft do the work of several of the earlier types. This aircraft replacement business is worth, in all, some £350,000,000 per annum.

What we need for this industry is a slice of that cake, and we have to win it in the hard, commercial world. We in the British aircraft industry are in

competition for the business predominantly with the United States, and to a lesser extent with France and Holland. The Americans have built their civil aircraft against their military background, which makes things difficult for the British aircraft industry and puts all the more responsibility on the British Corporations, as Lord Douglas has said, to give a lead to the industry on the types of aircraft that they will require six or seven years hence.

The responsibility has been clearly laid on the British Airways Corporations by successive Governments of both Parties. In the future these types will certainly include a supersonic transport. The major issue here is whether we in the U.K. should engage in a head-on competition with the U.S.A. for a supersonic airliner which the Americans will build anyway. Or are there possibilities of a collaborative Anglo-American approach? There may be room for an imaginative approach.

In any case, I believe that air transport is likely to diverge along two, parallel, lines of development in the future :-

1. the high speed — high fare direction; and
2. the low fares market — at moderate speeds.

conclusion

So, in conclusion, we can say that in all the 50 years of the British aircraft industry, there has never been a time of decision such as this.

The five decades since British aviation began have each been marked by significant factors :-

Decade 1
1910 - 1920 — Origin and growth through the First World War.

Decade 2
1920 - 1930 — The era of pioneer flights and the foundation of air transport.

Decade 3
1930 - 1940 — Monoplane evolution and foundation of production.

Decade 4
1940 - 1950 — Second World War — the decade of production.

Decade 5
1950 - 1960 — The era of the introduction of turbine aircraft and of unmanned flight.

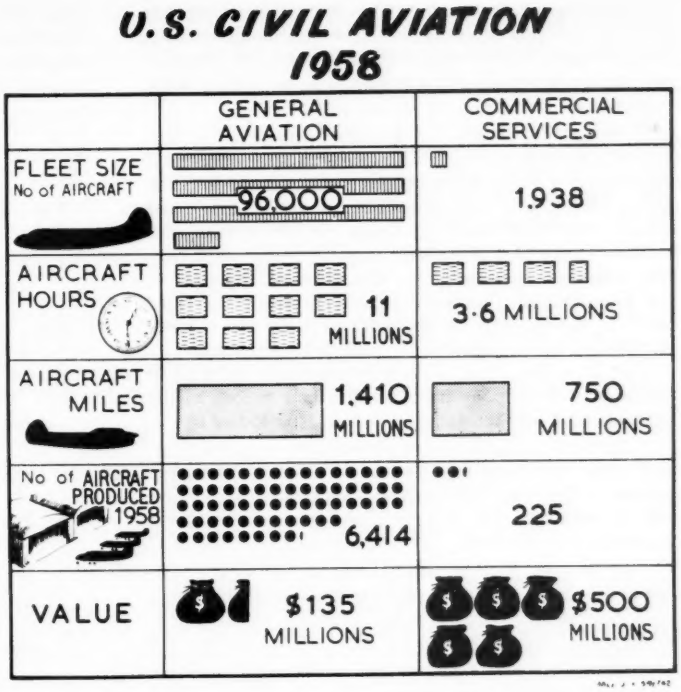

Fig. 24.

WORLD AIR TRANSPORT
1958
310 AIRLINES employ 300,000 STAFF
who operate 5,200 AIRCRAFT which fly in
the year 1,900 MILLION AIRCRAFT - MILES
producing 6,500 MILLION LOAD TON-MILES —
earning £1,700 MILLION in REVENUE.
95 MILLION PASSENGERS are flown
56,000 MILLION PASSENGER - MILES and the
CARGO and MAIL carriage totals
1,600 MILLION TON-MILES.
Spending on NEW AIRCRAFT is at the rate of
£350 MILLION per year.

Fig. 25.

Through all these 50 years, British aviation has been in the van of progress. Now, at the dawn of a sixth decade — the start of the second 50 years — we are entering the Space Age, the period of high supersonics, and perhaps of low production.

The position which the United Kingdom can and should carve out for itself in aeronautics in this new decade is, I believe, of predominant importance to the whole nation. The issues are far wider than those which any individual company or association can tackle. There is a dominant need for clear and concise thinking and for policy decisions on the part of the Government. In such a complex field, the right road to follow can be determined only by a comprehensive review against the widest background.

The situation can, in fact, be summed up well in the words of the Cadman Committee's report to the Government, written in 1938, but as true today :-

" Foreign manufacturers, American in particular, not only dominate the European market, but have gained a firm foothold in the Dominions, a position which national and Imperial reasons alike make it important to retrieve.

" If, as we assume, the Government desire this country to take a leading place in civil aviation, much re-organisation and additional expenditure of public money will be necessary.

" British aircraft constructors, without prospective orders for civil aircraft, cannot bear the heavy initial expense which must be incurred before manufacture can commence. *It is essential to formulate a specific programme of development which will ensure that the British operating companies are at all times using aircraft that are in the van of aeronautical progress.*"

And the Cadman Committee went on to recommend that the Government should "*form an Advisory Panel*" to "*specify broadly the requirements of a limited range of types of suitable air transport aircraft and should ascertain which constructors would be interested in the production of these types.*

" The Ministry would undertake to bear the cost of the jigs and tools necessary for the production of aircraft of each design. In the event of the aircraft being commercially successful, the State should obviously be entitled to recover the whole or part of its contribution to design and manufacture.

" The State assistance to the construction industry should be a reasonable supplement to commercial enterprise and should enable aircraft of an advanced design to be offered at prices competitive with those of foreign makes."

That was in 1938. It bears re-reading in the light of today's events. The position must be surveyed again as a basis for a new policy towards the future of British aeronautics.

Unless such a policy is determined the industry may well fade away into other pursuits. Unless such defence and civil orders as are available are planned to follow on in proper sequence, design teams — which have taken decades to build up to an irreplacable repository of knowledge — cannot be kept in being. Nor can production facilities, achieved at high cost, be kept potent unless there is a long-term solution to the constant problem of matching production requirements to production capacity — neither too much nor too little.

The problems are many and complex and the first requirement is to state them clearly. From that we need a policy for the years ahead.

Six points may perhaps be set down as a line of attack :-

1. *A policy of a strong British aircraft industry* should be established, with clear objectives, within the financial terms decided.
2. *A defined field of endeavour* should be set in the five main categories of aircraft :
   (i) transport;
   (ii) general aviation;
   (iii) manned military aircraft;
   (iv) guided flight;
   (v) helicopters.
   Within each category clear, if limited, targets should be set in both civil and military fields.
3. *State sponsored research and development programmes* should be planned to cover each of these categories, within the specifically defined areas.
4. *Financial support for a series of major projects* should be determined, on the principle that what is worth doing at all must be done adequately; and that research without production is useless.
5. *The responsibility of the State Airways Corporations* for initiating the development of British aircraft to meet their future needs should be defined again with clarity, and supported with money.
6. *A policy of encouraging British aeronautics generally* should be established, with particular reference to both the independent operators and to general aviation ; thus leading from the foundation of a healthy home market to expanding export sales.

As Lord Douglas has said : " There is nothing which a bit of realistic thinking and sensible policy-making cannot put right ", provided policy-making is supported by adequate funds to make it practical.

And as the Cadman Committee said in 1938, the objective should be " *to produce British aircraft and equipment which will satisfy the requirements of the British operators, out-rival competitors in world markets and enhance our reputation as a manufacturing nation* ".

Regrettably, perhaps, the financial ticket is the passport to success or failure. The millions which are being poured into aeronautics and astronautics by the United States and Russia cannot be matched except by adequate funds to compete in the selected fields. How limited these fields should be is the biggest policy issue of all.

In some quarters it has become almost sacrilege to question Treasury dictation on what should or should not be spent. One cannot repeat too often that, in an industry so bound up with national well-being, the inescapable fact is that unless a forward policy for British aeronautics is established, after the most careful analysis of all factors, and then that policy is implemented at the cost it requires to achieve success, then we shall fall behind for ever in maintaining our position as a world power.

Of one thing there can be no doubt. Whatever tasks are demanded of it, technically, the British aircraft industry has shown itself capable of achieving them at a lower cost than in either the U.S.A. or the U.S.S.R.

And so I say this — in these times of change and evolution, we need that clear statement of a Government lead which can be the only means of pointing the way ahead and of building on a foundation established through 50 years of endeavour.

DISCUSSION

In the Chair:
Mr. D. L. Wiggins,
M.I.Prod.E.

Mr. W. E. W. Petter, C.B.E., M.A., F.R.Ae.S. (*Managing Director, Folland Aircraft Ltd.*) thanked Mr. Masefield for his most stimulating and excellently documented review and suggested that the Institution of Production Engineers must possess some electronic machine which sampled the climate of the day, political and industrial, and on the present occasion had suggested the subject of "Where are we going?" The theme of the present Conference had been very well chosen, because they were on the verge of a new age; the whole situation was one of indecision, with a wide range of choices before them. Background information of the type which Mr. Masefield had provided was essential if they were to go in the right direction.

It was difficult to see how, in the face of the appalling development costs which had been mentioned, action could ever be justified when orders for only 20 or 30 machines could be envisaged. Lord Douglas had shown that British types of civil aircraft were rarely used in more than 40's or 50's, and that had to be accepted as one of the facts of life in this country. It was not good business to make only 40 or 50 aircraft, and if only ten were to be ordered the position would be much worse.

The British aircraft industry liked to be fairly independent, and would wish to be more independent of the official godmother than was possible in the circumstances. They had to recognise, however, the need for Government support. The excellent export figures achieved since the War had all been based on that nice lower part of the iceberg representing home orders, the *Meteors* and *Vampires* and *Canberras,* and even some of their civil exports had been at least indirectly assisted in the same sort of way. But that help had now been cut short and it would be necessary to ask for more rather than less Government support for the few projects which remained, especially if the numbers were to be very small.

Prestige was all very well, but it could be expensive, and practical considerations had to be taken into account as well as honour and glory. The industry had 80,000 skilled people to maintain in employment. It was not just an industrial problem of the industry being paid enough for its development work to get its money back; it was also a national problem of employment and exports. There was only a limited amount of money available to pay for employment, from which come exports, defence and prestige; prestige should be regarded as a "free issue", deriving from the other things, and should not be regarded as the primary objective.

Sir Claude Pelly had mentioned three new types of aircraft — the T.S.R.2; a medium-range freighter; and a large long-range freighter — which might slightly revive the aircraft industry, but it was hard to see how any but the third would lead to export orders to provide employment for a long time on production as distinct from development.

With this rather sad picture before the industry, Mr. Masefield had performed a valuable service by raising the whole subject of the supersonic transport. The cost of £300,000,000 for developing supersonic aircraft was one factor to bear in mind, but there were others. Work on this supersonic aircraft would use up far too large a proportion of the industry's technical man-power. There was not in this country the know-how which was available to the Americans, who had aircraft today which were cruising at M:2. The British aircraft industry would have to acquire that know-how by some means or other if it were to produce M:3 transport aircraft. It could not be done without grave danger of failure, and they could not afford to fail in a matter of this kind.

Mr. Petter thought, therefore, that Mr. Masefield was right, and that a thorough inquiry had to be undertaken. They must not be rushed for political reasons into a decision of such magnitude, involving

not only technical and financial but very important employment and export considerations, because it might, in effect, stop work in what could be very fruitful fields. There must be a wholly independent technical consideration of the problem on more practical lines than anything done so far. Mr. Masefield had pointed out the desirability, if the project were taken up, of a higher speed than those recommended by the Committee set up by the Ministry of Supply, and people concerned with business, finance and production must consider these vital points and study the whole matter thoroughly before the country launched out on an undertaking which might be beyond its resources, when compared with those of the United States and of Russia. That was a personal opinion.

The collaboration with the United States which had been suggested was worth considering. It might take many forms.

What alternatives were there in the development of the small general aircraft and in the military aircraft field? Why should not an attempt be made to develop an up-to-date Bristol Freighter with a simple form of turbo-prop engine? There should be a demand for such a type in the Commonwealth and in newly-developing countries elsewhere. There might also be a demand for a small Naval fighter. This country had sold four or five small aircraft carriers to countries, some in the Commonwealth, threatened by subversion, the cold war and local hot wars, but those carriers were languishing because there was not a small, up-to-date swept-wing fighter which could fly on and off their decks. Britain might make money, and play a useful role in helping to keep the world free, by meeting that need, even if it was not a large one.

In the last few years, Mr. Petter had travelled a good deal, in the Commonwealth in particular, and he knew that there was a very real fear in those countries that Britain, by trying to stay in the "big league," might leave them high and dry so far as provision for their more limited and less expensive needs were concerned. It was worth considering whether the British aircraft industry could not put some of its eggs in that basket, not only for prestige of the kind that mattered but also from practical motives.

He felt that Mr. Masefield had presented a most valuable Paper. Mr. Masefield had quoted the Book of Common Prayer, and Mr. Petter wished to do so as well and to express the hope that the Paper would enable them to avoid the pitfalls of doing those things which they ought not to do, and of leaving undone those things which they ought to have done.

Mr. Masefield expressed general agreement with Mr. Petter's remarks. On the particular question of what ought to be done, he said that certainly, as Lord Douglas had pointed out, there was a real field for a Viscount Replacement; the world wanted one, even if B.E.A. and B.O.A.C. did not. There was also the old and succulent chestnut of the DC-3 Replacement, and moves were being made there. There could also be, as had been suggested, a new examination of ways of getting costs down. On analysis he believed it would be found that the cheapest way of carrying people relatively short distances, though it was unfashionable, was by the use of two large, well-tried piston engines, unpressurised. If it were possible to sell an aeroplane of that sort and the public would ride in it, that would be the cheapest way of flying today. But would it sell?

The French aircraft industry provided an example of some of the things that Mr. Petter had mentioned; they had had a few striking successes in a limited field and it might be worth looking at the sort of approach which they had adopted. Mr. Masefield believed that there would be a real demand for a light aeroplane which would be a sort of "Jaguar car in the air," and that the R.A.F. could well spend a little money on a communication aeroplane of that kind. There was a great deal that could be done. Some of it might not be very sophisticated, but it would provide work, and work was what they all needed.

Mr. E. Turner (*Chairman and Managing Director, Blackburn & General Aircraft Ltd.*) congratulated Mr. Masefield on his Paper and said he was beginning to think that, almost for the first time, there were signs of a certain amount of agreement in the industry. Often it was found that the various companies disagreed so violently that it was impossible for the industry to have a policy, but he agreed wholeheartedly with almost everything in the Paper. He felt, however, that it did not do sufficient justice to the aero engine side. The aero engine business was still about 40% of the total business of the industry.

Mr. Masefield had referred to the divergence between high speed and high cost on the one hand and medium speed and low cost on the other, and there was a divergence on the aero engine side as well. The engine makers would be keener than most of the airframe makers to see the development of supersonic transport, because they were willing to sell their engines to the Americans or to anyone else. Below the supersonic level, where the great future of the British industry would probably lie, we had an advantage compared with the U.S.A. in our much lower labour costs, and if we could produce an aircraft in quantities comparable with those common in America, we could beat the Americans. It would not be possible to get those quantities in the field of supersonic aircraft, which was perhaps another reason for concentrating on the lower-cost, lower-fare business; but it was worth saying, in the presence of Lord Douglas, that until it was possible to get some real economics into aviation generally and have a suitable fare differential, however cheaply British production engineers could produce aircraft which were cheap to operate there would be no market for them, so long as the passenger had to be charged the same amount for travelling in a Ford Zephyr as he paid for travelling in a Rolls-Royce.

Mr. Masefield accepted the criticism of the Paper for its treatment of the aero engine side of the business. He had tried, he said, to be general rather than specific there, but he had in mind two Bristol Centaurus engines as the cheapest way of carrying 100 people, and he thought that if this country did come to collaborate with the United States on a supersonic aeroplane, British engines might be part of that collaboration. With the rest of what Mr. Turner had said he entirely agreed.

Professor E. J. Richards, M.A., B.Sc., F.R.Ae.S. (*University of Southampton*) said it struck him that not sufficient emphasis had been laid on the whole problem of increasing the domestic market in this country. There was always a tendency in aviation matters to look abroad and to assume that there was not likely to be a large development of domestic aviation; but, looking at other products of this country, we sold motor cars abroad because there was such a large sale for them here, and we sold whisky abroad because in the past so much had been drunk here. It was important, therefore, to see whether or not the domestic market for civil aircraft could be extended.

In that connection, he felt that there was a new and revolutionary step which could make a big difference, namely, the successful automatic landing and take-off achievements of this country. Aviation here had been hindered partly by the short distances involved but mainly, he thought, by the weather. With automatic landing and take-off there was good reason to try to expand the domestic services to a very large degree. He would like to know whether or not the extent to which the domestic services could be enlarged was in fact greater and whether, for instance, the development of air travel over distances such as London to Manchester had such promising possibilities that it would, like the consumption of whisky, open the door to greater exports, in this case of small civil aircraft. Had that been looked into? It seemed an important matter to investigate. There was a good deal of talk of putting satellites into space and building M:3 aeroplanes, but at a lower level there might be a good market which was being neglected.

Mr. Masefield agreed, but thought the question was more one for Lord Douglas to answer. He was delighted to see that B.E.A. had specified automatic landing for the D.H.121. The real problem presented by the domestic services, however, was that they were so expensive as a result of the tax on fuel which applied to flying within this country, and the very high costs of short haul. With automatic landing, however, it would be possible, as Professor Richards had said, to overcome that other great obstacle to the development of domestic air services, irregularity in the Winter. It had been Mr. Masefield's experience in his B.E.A. days (and he felt sure that it must have happened in the past Winter) that an early foggy period killed traffic for the rest of the Winter, because people were frightened off until the Spring. If that difficulty were overcome there should be much greater development of domestic air travel, and he hoped and believed that that would happen.

He felt that if only it were possible to get a small "executive transport" aeroplane flying in this country great use would be made of it, but it was necessary to get the Government to realise the importance of such a development. The attitude of mind which had led to the closing of Croydon aerodrome, which a few years ago had had more movements than London Airport, did not help this development. It should be made clear that this market could be important to British industry in the future. It was a market which should be developed.

Lord Douglas of Kirtleside (*Chairman, B.E.A.*) agreed up to a point with what Professor Richards had said but pointed out that the big problem was the short distance of the internal routes. With hardly any exceptions B.E.A. did not make a profit on any run under 250 miles; for instance they barely broke even on the London-Paris route, where there were a great many passengers, because the distance was so short. With a short run there was the whole business of landing fees, getting the passengers from the airport to the aircraft and putting them on board, and so on, and the same at the other end, so that it was difficult to make the fare cover the cost. That, he thought, was the main obstacle, though he agreed that automatic landing would make some improvement.

Mr. A. Vines, A.F.R.Ae.S., A.M.I.Prod.E. (*Production Director, Fairey Aviation Ltd.*) referred to one matter about which not much was said in the two stimulating Papers which had been presented. They were now looking six or seven years ahead. Anyone who had travelled by road from London to Southampton that morning would probably have followed a long string of enormous lorries creeping along the road. The railways had failed to provide a satisfactory service for goods; had they done so, there would not be so many lorries in use. Before long the roads would become completely congested with lorries and it would be necessary to take to the air for internal short-haul transport.

If there was to be efficient transport inside the country, and there was no alternative to the air for that transport, it would be necessary to provide an efficient transport service to other countries. Lord Douglas said in his Paper that the aircraft industry of today would have to replace the shipbuilding industry of former decades which built thousands of tramp steamers to deliver goods made in this country all over the world. At present the main air lines did not seem keen on delivering big consignments of goods over long distances, but it was necessary to have a really efficient transport system for heavy as well as small goods, and it seemed

probable that there was an enormous market waiting to be opened up for the efficient transport of goods not only inside this country or inside Europe, but covering the whole world. Such a service would require not 10 or 20 aeroplanes but hundreds, and possibly thousands.

A comparison of railway goods stations with passenger stations would give an idea of what would be required; there might be 50 runways with hundreds of freighters coming in and with short-haul planes to deliver the goods to the place of use. It should then be possible to show the world how to deal with the transport of goods.

Mr. Masefield said that domestically it might be a question of motorways as against internal air transport. He was not sure which would cost less. The market for air freight existed if the cost could be brought down. It was a question of cost per ton-mile. If the cost per ton-mile could be brought below, say, one shilling, there would be a tremendous field for development. But freight would not pay high ton-mile costs unless for special items such as gold or racehorses; for the "common or garden" stuff, it did not matter whether the transport time was two hours or 200 so long as the transport was cheap. At the moment air transport had not got the costs right, partly because it had gone after "speed at any price" and the aircraft industry had not been asked to produce a low cost aeroplane. If they were asked to produce an aeroplane which would carry 30 tons for 1,000 miles at the lowest possible cost, he believed that it would be possible to get down to the right figures. But they had never been asked to do it or been given an order on that basis. That was a challenge to the operators.

Mr. Vines pointed out that the aircraft industry had never advertised the fact that they could do it. He felt sure that the machine tool industry would gain enormously if it were able to ship its machines complete. Almost every machine from Europe came in with all the electrics corroded and unusable. The aircraft industry should sell the idea of freight transport by air.

Mr. Masefield agreed.

The Rt. Hon. the Earl of Halsbury (*President of the Institution*) asked Mr. Masefield to elaborate on the concept of very fast aeroplanes doing a shuttle service across the North Atlantic, so that only four were necessary. How would that fit the physiological requirements of passengers? No one would want to pay a premium with his firm's money in order to get up in the middle of the night or go to bed just before breakfast. Flying west the aeroplane would beat the clock and there might be a uniform loading, but flying east there would be a heavy peak load of people who wanted to leave at two o'clock in the afternoon and arrive in London at ten o'clock local time. It seemed, therefore, that the load would be peaked at one end and spread at the other.

Mr. Masefield, agreeing with Lord Halsbury, remarked that it had been said that the only way to get full utilisation of a supersonic aeroplane was to keep on going West. If one went from London to New York, San Francisco, Sydney and so back to London it was fine, because one arrived everywhere in time for breakfast. One reason why it would be difficult to make the supersonic aeroplane pay was that the utilisation would inevitably be lower than with an aeroplane taking longer on the journey, and the supersonic aeroplane would spend more time on the ground. A supersonic aeroplane carrying 150 passengers and making three round trips a day would suffer from the fact that no one would want to travel between midnight and 4 a.m., and the present difficulty in securing good utilisation of the seats would be multiplied many times by high speed.

He believed that when they examined the economics of the problem they would be horrified. He did not believe that pre-production costs of £300,000,000 could be written off. Somebody had to pay that cost, and the air transport operators would probably be asked to do so.

There were other problems, of which one was noise. It would be necessary also to climb up 35,000 ft. subsonic before becoming supersonic, which again would affect the utilisation of such aeroplanes.

Air Vice-Marshal G. R. C. Spencer, C.B., C.B.E. (*Technical Liaison Officer, Wm. Jessop & Sons Ltd.*) asked how, if only a few M:3 aircraft would be required, it would be possible to justify the manufacture of the 100 needed in order to make a commercial profit.

Mr. Masefield replied that it could not be done, and that was why he thought it unlikely that this project would come about. It should be examined from the wider aspect, because it would be foolish to say that they would not embark upon it because it was too difficult or expensive without being sure that all sides of it had been examined; but his point was that if there was a production of only 10, and they cost £30,000,000 each, they would not constitute an effective output from the production point of view for this country, or from the design point of view or from the operating point of view. Thus it might be found that the supersonic aeroplane was not worth doing. He did not want to be dogmatic about it before it had been examined in all its aspects. They did not want to rule themselves out of the "big league" until they were sure that the "big league" was not for them.

The **Chairman,** on behalf of the Institution and of everyone present, thanked Mr. Masefield for his Paper, and the Conference then adjourned until the following day.

PACKING FOR TRANSPORT AND EXPORT

by D. G. MILLER

A Paper presented to the Manchester Section of The Institution of Production Engineers on 23rd February, 1959.

SOME time ago, passing through London, I noticed an ordinary covered delivery van in an unimportant street unloading goods — eight wooden cases about 2 ft. 6 in. cube, marked "GLASS WITH CARE" and at a guess weighing about 1 cwt. These were apparently intended as stock for a warehouse. The driver of the van carefully placed an old lorry tyre cover on the road under the lowered tailboard and proceeded to slide and push the cases, one by one, over the end of the van to fall on the cover, from where they were trolleyed into a warehouse.

Neither a new nor a bad idea except for one thing — three out of the eight cases fell corner down through the centre of the cover, and this corner hit the roadway with a resounding thud.

I make no apology for this little story except that it leads directly into the first part of this talk — PACKAGING FOR TRANSPORT — which really means packing to meet transport hazards.

Both the driver and his tyre are a good example of transport hazards. The pathetic part is that one cannot say he acted completely without thought but rather that he acted without complete thought.

Let us start by considering the more normal hazards of transporting goods from one point to another. In the first instance transit hazards should, I think, be defined as follows :-

1. short duration,
2. rough handling,
3. attack by water.

duration

In my opinion, and it is purely a personal one, three weeks should be considered as the maximum period of a transit risk. This appears to be a reasonable time expectation for journeys in the British Isles.

★————————————————★

Mr. Miller was educated at Blundell's School and served an engineering apprenticeship with Workman & Clark Ltd. and Harland and Wolff Ltd. He subsequently moved to the aircraft industry and gained experience on aircraft tooling and design with Short & Harland Ltd. and Short Bros.

After a period of service with the Ministry of Aircraft Production, where he became Senior Aircraft Production Officer, he joined Export Packing Service Ltd. in 1949, and was appointed Chief Designer in 1950. He is now Chief Designer of E.P.S. (Research & Development) Ltd., where he is engaged on research and development into packaging and packaging material.

rough handling

Considerable damage can be caused by :-

1. the carriage of goods in road vehicles where the load is light and the vehicle's suspension system is therefore not operating fully, resulting in excessive bumping and bouncing of the cargo;
2. rail shunting, particularly where the process is hurried and also in certain types of yard where ramp shunting is used;
3. dropping, which is generally thought of in terms of the human element, but can occur with mechanical handling apparatus where insufficient care is taken;
4. overswing on cranes, where the arm of the crane is traversed and then stopped, the load carrying on pendulum fashion, and if the crane driver misjudges the cargo can hit some local obstruction, building, ship side etc., causing severe damage;
5. our friend the truck driver who is able, either on his own or with the assistance of a mate, to drag cases to the tail end of his truck and overbalance them into the roadway;
6. development of stacking pressures, usually where storage space is at a premium and the only way to save it is to utilise all available height.

water attack

Damage can be caused by :-

1. rain — easily achieved, since apart from the use of ply cases, softwood cases are not generally waterproof;
2. cases standing in water for considerable periods, particularly if outside storage is involved and local heavy rain or flooding occurs;
3. cases travelling as deck cargo and exposed to salt spray, and in rough weather, washing and sluicing with salt water.

These, then, are the generally accepted transport hazards, of which the majority can be encountered by packs travelling in this country.

To these must now be added the hazards to be expected if goods are exported, and these I would like to define as follows :-

1. The extended duration of the transport hazards previously mentioned.
2. Greatly increased risk of climatic hazards.
3. The possibility of storage under adverse conditions.

transport hazards

These remain as previously outlined, but can be accentuated due to increased duration and the advent of climatic changes, which may render the pack less able to overcome them.

climatic hazards

These include :-

1. moisture vapour penetration due to high ambient relative humidity coupled with acute temperature change characteristics;
2. mould growths;
3. insect attack, such as termite and syrex wasp.

If you will accept the foregoing definitions to cover transit and export, I would like now to consider the general approaches which a pack designer must make in order to arrive at a satisfactory pack, and I would like to discuss firstly the rough handling aspects.

Initially, there does not appear to be a great deal of information as to the magnitude of shock provided by various forms of transport, but there is one common factor which permeates pack design from beginning to end. This is usually referred to as "g" or the Impact Load Factor, and for this purpose I would like to define it as the force generated by a sudden change of direction of a moving body. This force is related to the weight of the body and as an example, if an item having a weight of 10 lb. is stated to have an Impact Load Factor of 20 or 20g, this implies an impact force of 200 lb. (10×20).

This I.L.F. can also be considered in terms of acceleration and deceleration, and it is usually due to movements of this type that the forces are generated. Some recent assessments in this country have produced figures which indicate that in the average transport vehicle carrying a cargo which is in constant contact with the floor, accelerations in the order of 2 to 3g are produced by the suspension system. If the vehicle is lightly loaded and the cargo is capable of bouncing approximately 1 in. off the floor, then it is possible to achieve figures in the order of 25 to 30g. Normal rail shunting carried out at about 6 m.p.h. can produce 8g, and dropping and crane overswing impacts can produce figures as high as 70 to 100g.

An American assessment of transport shocks produces the following figures :-

Air Transport
From 1g at 7 C/s to 20g at 500 C/s.
Road Transport
From 2g at 7 C/s to 7g at 100 C/s.
Rail Transport
From 1g at 15 C/s to $2\frac{1}{2}$g at 4 C/s.
Ship Transport
Stable at $\frac{1}{2}$g at 0 - 50 C/s.

Various figures of this type have been co-ordinated into a series of tests, sponsored by the Government and issued in their Packaging Specifications. These tests are related to varying weights of pack and without going into great detail can be summarised as follows :-

dry heat test

As its name implies, this test simulates desert conditions and is usually applied as a pre-conditioning test which shrinks and embrittles timber, etc., and tends to soften other materials such as preservatives.

The test consists of exposing the pack to a temperature of 140° ± 10°F with a maximum Relative Humidity of 40% for 48 hours. The pack then passes on to the . . . .

bump test

where the pack is clamped to the table of a bump machine in various attitudes, and is subjected to a test of 30 minutes duration in each attitude, consisting of three drops through 1 in. at 180 ± 20 bumps per minute. This is followed by a . . . .

drop test

where the pack is dropped in various attitudes on to a steel plate wet floated into a concrete block of 18 in. minimum thickness. The height of drop specified is related to the gross weight of the pack, being 4 ft. 6 in. for packs up to 150 lb., 3 ft. for packages of over 150 and up to 250 lb., 2 ft. for packages over 250 and up to 500 lb. For packages of 500 lb. and over, each end of the package will be lifted in turn 2 ft. if the length of the package is 11 ft. 6 in. or more, or to an angle of 10° if the length of the package is less than 11 ft. 6 in. and allowed to fall freely. Also in this weight range is the . . . .

impact test

where each end of the case strikes a 12 in. wide rigid beam at 6 m.p.h.

The accent now changes to tests geared to climatic conditions, the first of which is a . . . .

rain spray test

involving 30 minutes exposure to water spray on each of the four top corners of the pack.

immersion test

Here the pack is immersed to a depth of 6 in. in water at 60 - 80°F for a period of 20 minutes.

damp heat test

Where the packages are placed in a tropical chamber, the internal conditions of which involve a 24 hour test cycle as follows :-

12 hours at 95° ± 4°F, Relative Humidity 95 - 100%.

12 hours cooling with condensation, during which the temperature must fall to 68° ± 10°F for a period of not less than 5 hours, during which time the temperature shall be maintained at 68° ± 10°F, and finally a heating period during which the temperature shall rise to 95° ± 4°F and the relative humidity to 95 - 100%. The pack shall remain in the chamber for four complete 24-hour cycles.

These are the main checking tests in the schedule, but if required vibration tests, in which the package shall be vibrated for periods of 15 minutes in each of three directions throughout the range of 1 - 15 cycles per second and at an amplitude of .05 in., can be called for.

An additional Drop Test may be required, also a Static Load Test and in certain instances a long term Storage Test.

Of these tests one has been selected as the basis upon which pack protection is calculated. This is the Drop Test, and at this point we now return to the "g" figure or Impact Load Factor where it is related to a specific cargo. In this instance, if a cargo is said to have a "g" figure or I.L.F. of 20 we are, from the packaging aspect, saying that it can absorb a shock equivalent to 20 times its own weight without breakage.

Assuming that a "g" figure is available for a given cargo, the next step is to select a cushioning material or suspension system which will best suit the static and dynamic conditions. The static conditions demand that the static load of the cargo shall not be sufficient to create permanent distortion of the cushion or suspension system. The dynamic aspect demands that the cushion will deflect the required amount in order that the deceleration of the cargo will be held below 20g, i.e., the Impact Load Factor of the cargo.

There is a very simple formula which can be used as a guide to the selection of a suitable cushion or suspension system. This is $g = \frac{2H}{d}$, where "H" is the height of drop test in inches, "g" is the Impact Load Factor of the equipment and "d" is the deflection required from the cushion or suspension system.

There are now available several good cushioning materials in the form of expanded rubbers and plastics, rubberised hair and high deflection rubber mountings, and in general the available dynamic data will make the selection of a cushioning material a simple process, particularly where the I.L.F. is above 15. It can, however, be a considerable problem where the I.L.F. is below this figure, and the static load is not great. This problem arises because there are not many cushioning materials of ultra light density and high deflection, and since from a 4 ft. 6 in. drop height an item having an I.L.F. of 10g would require a deflection of 12 in., it can easily be seen that an item of small proportions and light weight would either have to vanish down a well in the cushioning material and re-emerge or, due to its light weight, would fail to deflect the cushion fully.

I regret I have no answer for this particular problem.

Now, a word more about this elusive Impact Load Factor. This is really the key to all good packaging design, and strangely enough is one of the most difficult figures to obtain for any equipment. Except in the case of certain Government equipment it does not form part of the normal design requirement of any type of structure, but it is of the utmost importance when the item has to be packed and transported.

It is a figure which the Design and Stress Office should be able to supply, but in many instances cannot, and generally speaking the only accurate way of finding it out is to break up at least three of the equipments concerned under calibrated test conditions, in order to find out at what shock level or in what vibration frequency range they break up.

Quite likely you may say: "Is it worth while?" I can only suggest for your consideration the following data:

Assume that a 12 in. cube has to be packed to 20, 30 and 40g. This "g" figure would produce three packs in the order of 35 in. cube, 27 in. cube and 24 in. cube assuming a 4 ft. 6 in. drop test. This provides a maximum variation in the order of 17 cu. ft. which on a large consignment could mean an up-draught of 100% on the shipping volume. Apart from the protection achieved, I think this is the most important point in favour of accurate "g" figures for the packing of equipments.

Having taken some steps to safeguard the cargo from physical damage, let us now look briefly at the steps to be taken to protect it against climatic hazards. Generally speaking, preservation of this type falls into two categories: (a) hard and soft preservatives such as lanolin and beeswax compounds, and (b) the various ranges of greases and oils. These are mostly used to cover machined surfaces and for the more robust types of machinery, and in general are more suitable for transit and the shorter duration export exercises.

Where the complexity of the equipment, however, will not allow of their application, then a desiccated barrier system should be used and this in particular where long storage under adverse climatic conditions is expected.

These barrier materials are interesting, and the commonest forms are:

1. laminated foil and polythene, both of which are heat sealable;
2. a new plastic-metal material which is high frequency sealed and can be provided with a form of plastic closure which is nominally moisture vapour proof and is re-usable;
3. liquid plastic spray application and metal containers which are either soldered, welded or gasket sealed.

All these barriers are best used with desiccant such as silica gel or activated lime to obviate the danger of condensation. Each of the materials, with the exception of metal, has a moisture vapour penetration rate, that for laminated foil being 1 gramme/sq. metre/24 hours, and for .018 in. polythene 2 grammes /sq. metre/24 hours. Plastic and metal barriers would appear to be less than 1 gramme/sq metre per month, but this is not finally established.

This moisture vapour penetration rate is used to assess the quantity of desiccant required, the standard formula being:-

$$\frac{ARM}{60} + \frac{D}{2}$$

where "A" is the area of the barrier in sq. ft., "R" is the moisture vapour penetration rate, "M" the storage period in months and "D" the weight of hygroscopic dunnage within the barrier in lb.

We are now at the stage where the main risks are known and the "tools of trade" in the form of two simple formulæ and various materials are available. The next stage is how to apply them.

I understand that the major interests represented at the present meeting are machine tools, diesel engines, factory machinery, aircraft, electrical equipment and instruments, and I would like to group them as follows:-

Group 1. Machine tools, diesel engines and factory equipment.
Group 2. Aircraft.
Group 3. Electrical equipment and instruments.

1. machine tools, diesel engines and factory equipment

The main characteristics of this type of cargo are that they are physically strong but, due to the high incidence of castings, can be damaged by impacts of low time duration which tend to fracture castings. Also, they are particularly prone to corrosion damage due to the number of machined and ground surfaces.

The first approach should be a detailed examination of the equipment to assess any weak points from a packaging aspect. In this range, these usually take the form of relatively large masses situated high up in the structure and often in themselves mobile in relation to the main part of the structure.

It is always a good thing to assume that no matter what precautions are taken it is possible for a pack to travel in any position, and therefore all parts of the cargo structure should be examined with this in mind and the question asked "Would you be happy if the cargo were turned upside down or into any other position but the normal, and subjected to shock"? Where the answer is "No", then consideration must be given to dismantling the dangerous items where this is possible, or alternatively creating within the pack some furniture or strutting which will satisfactorily strengthen the items concerned to withstand this form of treatment.

Many machines also have a form of motor mounting which, unless it can be removed, is dangerous while in transit. This usually takes the form of a platform hinged on one side and carrying a driving motor operating through a belt system, the swinging platform being used to control the tension on the belts. The mechanism controlling the amount of movement in this platform is seldom strong enough to withstand the order of shock generated by the platform, and if it breaks, or if the hinged points of the platform are insufficiently strong and break, then considerable damage can result from this loose weight moving about within the equipment.

Generally speaking, the holding down bolts or lugs cast in the bed-frames of machines are not strong enough for packing purposes, and it is better to surround the base of the machine with a sill or frame which contains it, and then to apply downward pressure by means of additional furniture over the top of the machine to maintain it within the sill.

Unless actual tests have been carried out, it is practically impossible to assess an accurate Impact Load Factor for this type of equipment, but some

elementary calculations based on the cross-sectional area and shear stress of weaker sections may help to establish a usable figure to work upon. If sling irons are to be used on the case carrying the equipment, the position of these should be intelligently related to the C.G. of the cargo.

For this type of pack, cases having exceptionally heavy strong base structures should be selected, the bases being of the skid or frame type. When designing these it is a good approach to imagine that the complete cargo should be lifted on this base using it as a pallet, without the additional strength supplied by the sides and ends.

The next approach is to examine the equipment from a corrosion aspect. Note should be taken of mixed metals in contact which are likely to aid corrosion electro-chemically, and also of machined or ground surfaces.

In the case of machine tools, particularly, the surfaces under travelling saddles should not be forgotten. For short duration transport all the machine surfaces should be well covered in soft preservatives such a lithium grease, and preservative oils. For longer periods, hard preservatives are better and in the case of protracted storage a moisture vapour barrier would be essential.

In the case of petrol or diesel engines, normal engine inhibiting should be carried out by the manufacturer after test, and all inlet and exhaust apertures sealed off.

When a moisture vapour barrier plus desiccant is considered necessary for this group of equipment, bear in mind the heavy loadings involved where the barrier passes under the cargo, and endeavour to spread the load over the barrier as evenly as possible. A sturdy ply deck or raft can often achieve the desired result.

It may be of interest that between 1956 and 1958 a test was carried out to assess protection offered by the then standard form of pack for Government machine tools, which involved soft preservation and a waterproof barrier against a new approach which utilised hard preservatives and a desiccant moisture vapour barrier.

The "guinea pig" packs, each containing an identical new lathe, were sent to the Tropical Testing Establishment, Port Harcourt, Nigeria, travelling deck cargo, and there spent some 8 months on a jungle exposure site. After checking they were transported some 500 miles by road to Lagos and there put for a further 5½ months on a marine exposure site on the beach. The ambient conditions on the jungle site were in the order of 90 - 95% relative humidity, annual rainfall 95 in. and average temperature 80°F. Similar conditions prevailed on the marine site, but with the added hazard of salt air and spray and fine blown sand.

The packages eventually returned to the United Kingdom as deck cargo, and upon examination it was found that the traditionally packed machine was unserviceable due to rust and corrosion, but the machine in the new pack was serviceable and operated satisfactorily when power was supplied.

An interesting phenomenon which, while not frequent, can cause considerable embarrassment, can arise from a too-direct form of packing. This occurs on equipments which have ball or roller races fitted, and is divided into two forms of damage, false brinnelling and fretting corrosion.

A rough definition of these two conditions is as follows :-

False Brinnelling takes the form of a breakdown of the surface of the race caused by too high a loading at the point or line of contact of the ball or roller accepting the main load. A hammering or vibration similar to rail transit conditions is most likely to cause this effect.

Fretting Corrosion. This is a more complex sequence of events, and possibly the elementary explanation is that no matter how finely finished, a micro-examination of a machined metal surface will look like a cross-section of the Alps. If two such surfaces are in contact and are then vibrated, the peaks of the Alps will be knocked off and fall into the valleys. This allows virgin metal surfaces to be exposed and oxydisation commences. The debris resulting consists of a complex mixture of metal and oxide and since the amplitude of the vibration provides insufficient movement between the surfaces to sweep this debris away, abrasion is added to the general destruction.

This particular type of problem, although present in individual instances in engineering for some time, was brought into the limelight from a packaging point of view when the Americans endeavoured to transport jet engines trans-continentally by rail, and it was found that many cargoes had ruined bearings before having done any work other than their test running. Although not yet fully complete, the study of these two problems would indicate that two forms of prevention should be used in conjunction — special lubrication and auto-rotation of the rotating masses. A further approach can be made if it is possible to establish the precise frequency and amplitude of the vibrations which affect a particular equipment, and to insulate the equipment from this range of vibrations by a suitable filter medium.

2. aircraft components

This group covers the major spares components of aircraft, engines and ancillary equipment.

Looking first at the major components, which are usually aerofoils, control surfaces, fuselage sections, etc., there are several problems facing the pack designer. In many instances, there is a lack of strong attachment points which can be conveniently used for holding the components in the case, and as the current trend of opinion quite rightly deplores the use of contour formers which tend to transmit case distortion to the component, considerable ingenuity has to be exercised to hold the component successfully. It is, however, possible, by the use of properly made metal brackets, to make use of hinge points and spar attachments, but caution must be exercised, particularly if spherical mountings or ball faces are

fitted, and in the provision of suitable bushes for holes.

However, I feel that the design approach for this type of equipment should embrace the following points :-

Initially every effort should be made to utilise the main attachment points used for the assembly of the aircraft, since obviously these are well stressed to withstand distortion. It is also desirable that in selecting these main holding points, an attempt should be made to dispose these along the axis of the case, or alternatively to triangulate the pickup points.

A common form of this technique is found on wing packs, where the root ends of the main spars are attached to the end of the pack by way of metal brackets and rubber mountings, which provide the necessary flexibility required to insulate the component from case distortion. The outer end of the wing is carried in a frame steady, side pressure being taken by rubber pads bearing on the spar lines where the item is virtually incompressible. Vertical movement can frequently be contained by the use of a long well-cushioned shoe under the leading edge, which is traditionally packed downwards at or adjacent to the frame steady, and also by using one of two of the aileron hinge points acting against rubber pads to prevent upward movement.

In all large aircraft components it is essential to study the effect of case distortion, as many of the cases have a poor girth-to-length ratio. I would also add that the use of rubber mountings does not imply cushioning as such, but purely as a form of universal mounting which will allow case distortion to take place but will not transmit this distortion to the component.

The type of case or container used for large aircraft sections should be considered. R.A.F. practice for some years, which has proved satisfactory, makes use of a transit cradle for large components, which usually takes the form of a rectangular timber framework carrying within its dimensions the component concerned. This type is used for transit in this country only and is usually referred to as a " restricted " container. Since the Service may also have to send components overseas, it is usually the practice to produce a case design at the same time which will readily absorb the furniture and attachment points used on the cradle, and if the component is going for export, it is transferred into this type of case.

In many instances, the cases for this type of component are large and have very considerable areas of sheathing. The likelihood of panting taking place is strong and the advisability of introducing internal cross or diagonal strutting from side to side of the case must be considered. All large openings in the component should be blanked off with a waterproof paper or other barrier, and these are generally taped into position.

Where the skin of the component is polished, metal finish hard preservatives should be applied to take care of corrosion.

This approach has been found satisfactory over a period of years, and although the lack of cushioning or suspension systems may seem odd, this is largely brought about by the comparatively large nature of the equipment in relation to its weight. In the case, however, of the smaller spares items, cushioning of the wood wool float or rubberised hair type is often employed.

With regard to the packing of aircraft engines, and in particular jet engines, this has opened up a complete new field of requirements and design problems. Engine packs are now required to undergo rough handling and climatic tests, not only by Government departments, but frequently by the engine manufacturers themselves, the reason being that the average jet engine has an Impact Load Factor or " g " figure of about 10, and in order to survive the tests packs must be designed with suspendsion systems allowing deflection in the order of 4 in. and capable of handling loads of the order of 2,500 - 5,000 lb.

It is usual to pack engines on a transit stand and then to suspend this stand within the case. The design approach is to consider first of all the engine stand, which is also frequently used apart from the case as a servicing or overhaul stand. These are usually made from either steel section or tube, and must be designed to offer the maximum accessibility to the engine and be stressed to accept shocks somewhat in excess of the Impact Load Factor of the engine itself. I can assure you that there have been cases of engine stands collapsing during testing, because of this factor not being fully appreciated. In addition to this, provision must be made on the stand for the acceptance of the moisture vapour barrier.

The next approach is to devise a suspension system which can cope with the combined dynamic load of engine and stand, and produce the required deflection. At present the commonest form is to use high deflection rubber mountings, to which are allied hydraulic dampers, since the natural frequency of the system falls within the frequencies generated by transit conditions. Successful designs have also been produced using hydraulically damped coil spring units similar to those employed on many vehicle suspension systems.

It is essential that a first-class barrier material be provided, since it is not feasible to preserve jet engines with any of the normal ranges of preservatives, and barriers to-day are faced with an exceedingly difficult new hazard in that many of the lubricating oils used for jet engines are capable of acting as solvents to most of the plastic materials available; therefore considerable attention must be given to the selection of a suitable material.

In relation to the transport of jet engines, may I remind you that this is one of the fields wherein false brinnelling and fretting corrosion of bearings can flourish.

3. electrical equipments and instruments

As representative types of equipments which fall within this category I would suggest electronic racks and cabinets, computer and radar equipments, radio sets, player desks, tape recorders, voltage and amperage meters, etc.

This range of equipment, because of its great variation in structure strength and vulnerability from vibration and shock aspects, requires the most accurate form of packing that can be devised and also the closest study before any attempt is made to design a pack for it. It is in this range that the full implication of the "g" figure or Impact Load Factor becomes apparent, and also, because it is not possible to apply skin preservatives to this type of equipment because of the complexity of its make-up, anti-corrosion technique must be of a high order.

These factors, therefore, lead the approach to successful packing into two definite lines :-

1. the provision of maximum physical protection and
2. moisture vapour barriers plus desiccant.

As usual, the first approach is a detailed analysis of the equipment itself in order to segregate the weak and strong points for consideration. It will frequently be found, in carrying out this exercise, that although the structural strength of the equipment is ample while it is comfortably contained in its can or rack, for it to perform its duties satisfactorily, any attempt to rough handle it would cause disaster. Common forms of danger encountered are large oil filled chokes and condensers attached to light alloy decks by means of B.A. screws.

Again, if one considers these when the equipment is on a side or an end and is subjected to shock, the full implication of the cantilevered masses and forces generated will be realised.

Another difficulty which is frequently encountered is the provision on a heavy chassis of a comparatively lightweight guard rail system which can only barely support the weight of the equipment for repair handling on a bench, and is certainly incapable of supporting any shock loadings. This type of factor makes clear the necessity for an accurate Impact Load Factor for the equipment, and it is only if this figure is reliable that an efficient pack design can be evolved.

The general approach to this type of packing is to hold the equipment between felt faced blocks or surfaces within a light ply case. This case is then cushioned with a suitable material or suspension system into an outer container. Where possible the moisture vapour barrier should be positioned around the equipment itself in order to obviate any unnecessary hygroscopic material within the barrier. In doing this, great attention must be paid to any sharp projections on the equipment which could puncture the barrier and these must be padded and masked before the barrier is fitted.

Where it is not possible, by reason of the nature of the equipment, to put a barrier directly round it, the next best approach is to put the barrier round the outside of the inner box, and to make allowance for the increase in desiccant to cover the box and its furniture now included within the barrier.

Tests carried out on some hundreds of packs of this nature have shown them to be satisfactory both from a rough handling and a corrosion prevention aspect.

Many times the question is asked "Why should a good equipment be risked in a pack test?" This can be avoided if an accurate Impact Load Factor exists, and the method is to use a resonant free dummy load in the pack which has the same load distribution as the original equipment. This is instrumented with an accelerometer and recordings taken; if these compare favourably with the I.L.F. stated then the pack can be accepted. But remember that an equipment, or more than one, may have to be sacrificed to obtain an accurate I.L.F.

If taken in detail, any one of the groups of equipment so briefly covered in this Paper could provide material for a course on packing in itself, and therefore, in a short review, the detail has had to be neglected in favour of a broader approach which if disappointing, will I trust be forgiven.

And now to sum up — in producing a pack for any given unit of equipment :-

(a) examine it carefully for strength and weakness;

(b) consider possible effects of shock with the equipment in any attitude — think spherically — attack can come from any direction;

(c) endeavour to establish an I.L.F., however loose it may be, and then with a cushioning or suspension system work towards it;

(d) assess the corrosion danger and use preservatives or moisture vapour proof barriers and desiccants;

(e) select or design a suitable case, the strength of which is in relation, not to the static, but to the estimated dynamic loads;

(f) Finally, review the types of transport hazard which you expect the pack to meet and check whether you have guarded against each.

COMMUNICATIONS

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THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL,
10 CHESTERFIELD STREET, MAYFAIR, LONDON, W.1.

Partial Line Assembly of Machine Tools

a thesis by

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THE object of this Thesis is to offer a means of reducing costs in the machine tool industry by improving labour and space utilisation with the application of "partial" line assembly.

The urgent need for better labour utilisation has been emphasised by Mr. H. P. Potts, M.I.Mech.E., Past President of the Machine Tool Trades Association, when he stated that the machine tool industry :-

> "side by side with a production which *in spite of a desperate shortage of* skilled labour, designers and technicians, is constantly increasing and advancing in original design." (*Institution of Production Engineers Journal*, Vol. 35, No. 6.)

One of the best ways of getting over the shortage of skilled labour is to ensure that effective use is made of every minute that a man spends on the shop floor.

A high proportion of the machine tools produced in this country are assembled by "batch production methods". That is, the machines are laid on the floor in batches and the fitters move from machine to machine completing their work. This method is considered by the writer to be wasteful of space and labour. These faults can be overcome by a system of "partial line assembly".

This type of assembly is said to have originated from the technique employed by the Chicago packers for dressing beef. This was to pass a complete animal carcass, on an overhead conveyor, down a line of butchers. Each man removed a particular joint while standing in a fixed position. This process of disassembly continued until nothing was left of the carcass.

The motor car industry reversed this process, and built up from chassis to complete motor car on a continuous conveyor. Both these methods brought the work to the man.

In the case of this industry, Henry Ford, who was one of the pioneers of line assembly, reasoned that pedestrianism on the shop floor could never be highly paid, or productive; therefore the whole object of planning and layout should be to eliminate this.

Application of line assembly has this effect. It reduces overall costs, and allows for higher earnings among skilled men. The last factor attracts and retains the best possible type of labour.

Consider the wages paid to the assemblers in the motor car industry and compare them with those paid to the assemblers in the machine tool trade. It is a fact that the former are paid more. A contributory factor to this is the high proportion of walking about made necessary by batch assembly of machine tools.

Visibly, the industrial process consists of passing materials through hands and machines. In fact, it is passing materials through time. The object of line assembly is to convert material into saleable goods in the shortest time.

The work of building machine tools can be broken down into two groups, the building of sub-assemblies away from the machine, and "fit to machine". For the purpose of this Paper, the work content under review is "fit to machine". Where comparisons are made between batch and line assembly, it is between the work of "fit to machine" only. The building of sub-assemblies is the same for both methods.

Some of the smaller machine tool units come almost into the category of sub-assemblies. The technique therefore for assembly of unit heads, described later, can well be applied to this type of work.

Schemes for partial line assembly will differ considerably between products. The general approach to the problem, however, will be the same. This is, to list the logical sequence for the "fit to machine" work, then try to anticipate every conceivable solution to the problem of how best to complete this.

It is necessary to define the problem. What is the weight of the parts? Which is the logical order for assembling? At which stage can these best be fitted to machines? Can any of the sub-assemblies be broken down still further? Which sub-assemblies have to be fitted in strict order? Which can be used to balance the required output at a particular stage? How many stages? How many hours at each stage? How many men are required for the given output? And so on, until a complete picture of the work content is built up.

Detailed analysis must be made of the work carried out at every stage, with the object of presenting the work in the correct sequence and at the right height for easy assembly.

Finally, we must consider the checks required against the output standards set and the actual achieved. Partial line assembly, properly controlled, will give a day-to-day comparison between actual and standard performance, and enable action to be taken to correct any deviation from the standard.

why "partial" line assembly?

(a) analysis of batch assembly methods and comparison with line

Let us consider the assembly of a machine tool with 40 hours "fit to machine" work content, to be produced at the rate of 10 per week by the batch method, using one man, one machine.

The machines would have to be laid out in, say, two banks of five, and 10 fitters would have to carry their tools and materials to the machines during the course of erection. This would entail making many journeys, backward and forward from the work or storage benches to the machines. Using one man per machine would mean having 10 sets of any special tools required for assembly.

If we use more than one man on each machine, the amount of walking about is multiplied by the number used. Thus, if the 10 men were employed on all 10 machines during the course of the week, there is a 10-fold increase in the amount of walking about.

Applying line assembly to achieve the same output of 10 machines per week, we would split the 40 hours work on each machine into five daily eight-hour stages, with two men at each stage.

At the commencement of each shift, two machines would be positioned at each stage for completion. The fitters would have their tools and materials pre-positioned adjacent to the track to eliminate unnecessary walking about, and to ensure that the maximum amount of time was spent on skilled productive work.

(b) the problem of low rates of production on complicated machines, and need for compromise between complete line assembly and batch assembly

Machine tools in the United Kingdom may be produced at rates per week that vary from one to 20. Even the highest of these rates of production do not in any way compare with those of the motor car manufacturer's rate of one car completed every few minutes.

Because of the high rate of production in the latter industry, it is possible to apply the principles of true line assembly production. The complete motor car, from chassis to the final running test, is conveyed down the assembly line at a continuous rate.

These schemes, however, call for large capital outlay and often extensive reconstruction of buildings. Notwithstanding this, many of the advantages of true line assembly can be obtained without this outlay while at the same time utilising existing floor space to better advantage by a compromise scheme. This is based on the careful selection of the work content to be carried out on the line, and of work more suitable for batch assembly.

Because only part of the work is carried out on the line, this method is called "partial" line assembly.

Consider the assembly of an automatic lathe with anything from 1,000 to 1,500 parts, many of which have to be built into complicated mechanisms. Some of the mechanisms will have to be built in a dust-free atmosphere and fitted to the machine as a sealed unit. Other mechanisms have to be built into the main structure of the machine *in situ*. The latter parts are essential for "fit to machine" stages.

The breakdown of work into units and "fit to machine" elements will reduce the work carried out on the line. This, in turn, will reduce the overall length of the line. It will also ensure that the distance between "fit to machine" stages is kept to a minimum and that the space taken up by the machines on the line is used as a working area.

anti/post line operations (Fig. 1)

when to start and finish the line; lengthy operations that have to be carried out with machines level and stable; initial line-up and running tests

In order to arrive at the most suitable point at which to start or finish the assembly line, it will be necessary to consider the work that will have to be carried out when the machine is in a stable and level position. Also, consideration must be given to any lengthy "fit to machine" operations that cannot be broken into small enough elements to fit in with the daily rate of movement.

Taking an automatic lathe as an example, an early operation is to fit the cross slide blocks and turret slide blocks and align them with the headstock. This

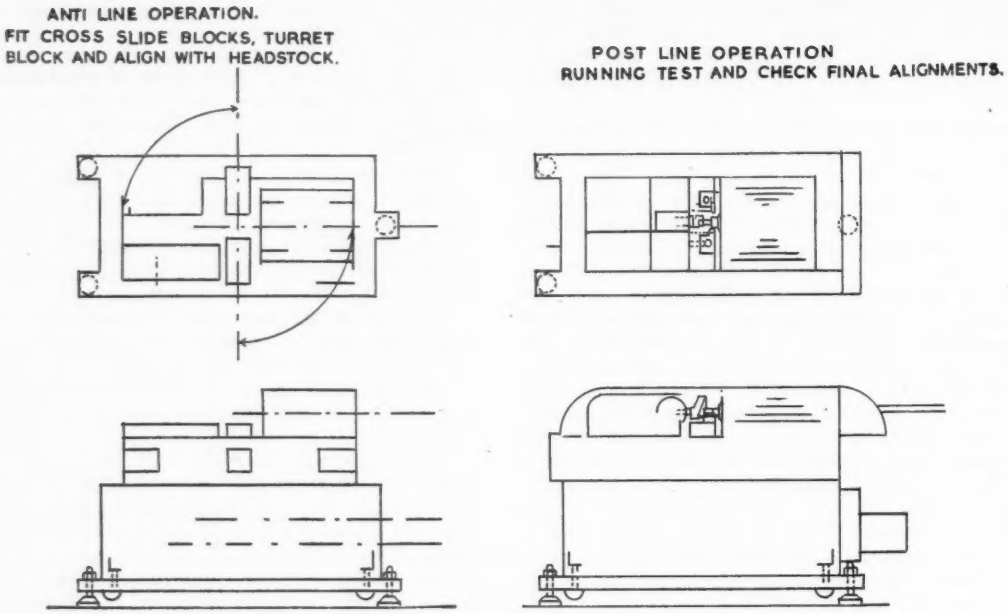

ANTI LINE OPERATION.
FIT CROSS SLIDE BLOCKS, TURRET BLOCK AND ALIGN WITH HEADSTOCK.
POST LINE OPERATION
RUNNING TEST AND CHECK FINAL ALIGNMENTS.

Fig. 1.

is a somewhat lengthy operation and it is essential that the machine is level and stable in order to take correct alignment checks. Another operation in this category is the initial lining up of backshaft brackets in order to provide fixed datums for subsequent alignments. The completion of this type of work can be used as the best point at which to commence the "partial" line assembly.

At the other end of the line we have a running test. Here again, the conditions are similar to the initial alignment check in that the operation is lengthy and the machine must be stable and level. The line should, therefore, finish immediately prior to this operation.

machine tool design

unit construction advantages for assembly; testing and service; variations on basic machines to give different capacities; attachments fitted to standard headstocks

The practice of designing machine tools on the unit construction principle has many advantages when we come to consider assembly methods. For instance, it means that we can take a wormbox or a gearbox, build it and run and test it before it is fitted to a machine (Fig. 2).

This will eliminate the possibility of faulty mechanisms being fitted to the machine and then having to be replaced. Also, it enables units such as worms and wormwheels to be run in without entailing excessive running time on other parts of the machine.

In connection with design for production of motor-cars, Sir Leonard Lord has said :-

> "The designer must also pay attention to post-sales service. Ease of servicing is one of the great factors in securing those very essential repeat orders, hence accessibility of those parts that are liable to need service is most important. Unit construction, which enables complete units of mechanism to be replaced promptly when trouble occurs, is invaluable in this connection."
> (*Institution of Production Engineers Journal*, Vol. 34, No. 11.)

This factor is equally important in the field of design for machine tools. The breakdown of a highly productive machine can have a very serious effect on a balanced production programme.

In regard to variations of basic design on machine tools, the one most common on lathes is that of spindle capacity.

The adoption of standard unit construction does, however, have some influence on design.

One instance is a standard unit headstock. Several alternative spindle capacities can be offered by using standard diameter housings with varying bores to suit the bearings for larger or smaller capacity spindles.

The possible disadvantage here may be that a larger headstock would cost more than one designed to take a small spindle only. This factor has to be weighed against the advantage of variety reduction and the possible advantage of greater rigidity in the larger headstock.

There is another important reason for standard units, such as headstocks on lathes. A unit such as this, covering several models, enables attachments to be interchanged. This gives greater flexibility to the plant in question.

On the subject of special purpose machine tools and unit construction, Mr. J. C. Z. Martin, D.L.C., A.M.I.Prod.E., said :-

> "The idea of standardised machine tool units or elements is relatively new, but it has certainly received a great deal of attention during and since the recent War. It is interesting to note that the idea is not only being developed and exploited by machine tool manufacturers, but also by large users of machine tools. At least two large motor-car manufacturers, one in this country and one in France, have designed ranges of machine units.
>
> "Modifications of products or complete changes of products do not necessarily entail the scrapping of the entire special purpose machine. The individual units, which form the machines, can be re-used by building them into machines to suit new requirements. Unit construction can simplify maintenance. Defective units can be removed for repair and overhaul, while replacement units are fitted in their place. The down time due to breakdown is therefore reduced." (*Institution of Production Engineers Journal*, Vol. 33, No. 11.)

The special purpose machine tools mentioned in this statement, such as transfer lines, are built to carry out certain operations on one part only. Owing to the special nature of this type of machine, they are not suitable for line assembly building. The standard units, however, used in many different special purpose machines, are ideal for this method of assembly, particularly if we have a basic unit to which various sub-assemblies are fitted.

It is recommended that these units be assembled on a raised track. This will ensure the correct working height for the various specialists to assemble their hydraulic and electrical equipment. It is also important that these men have all their tools, testing equipment and component parts, within the area of easiest reach.

When conditions like these exist, workers will spend the maximum amount of time on productive work.

This assembly technique could be applied to the completion of sub-assemblies used on either batch or line assembly.

manufacture of parts

interchangeable manufacture; extensive use of jigs and fixtures; grading of parts instead of selective assembly by fitters

In order to achieve the best conditions on assembly work it is necessary to ensure, at the machining stage, that the drawing tolerances and fits are obtained. Assembly operations such as spotting off drilled components from one part to another, must be eliminated by the use of drill jigs. In short, *the work of assembly must be pure assembly* and must not include filing or adjusting parts to suit or correcting hole centres.

A good illustration of this point is to be found in Mr. McNulty's Paper on "A Quarter-Century of

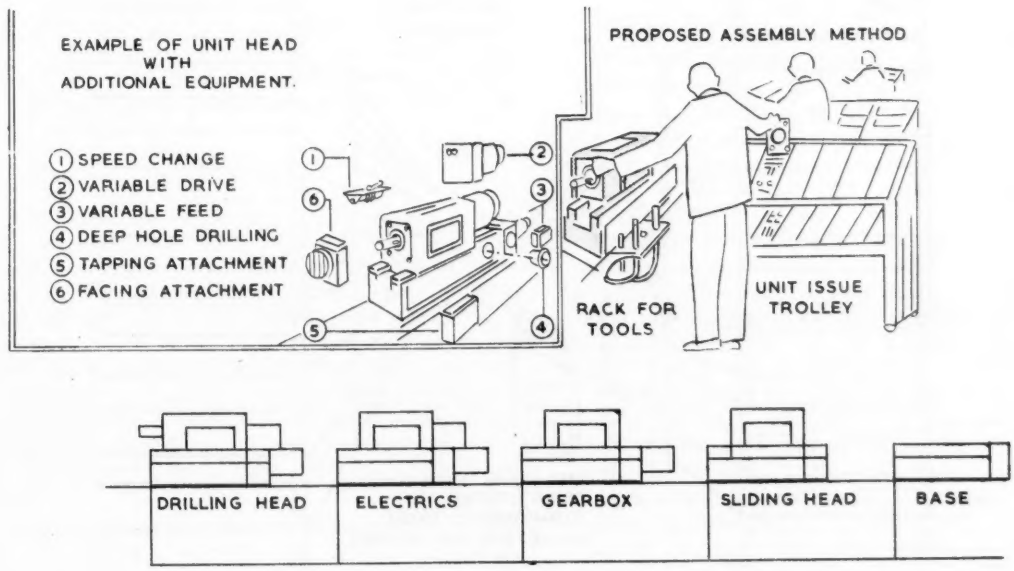


Fig. 2.

Progress in Ford Production Methods". In this Paper he describes the technique used in other War-time factories for assembly of fighting vehicles . . . .

> "It was unusual to find any special tooling lay-outs, and nearly all the machining operations were carried out by skilled operatives or at best trained dilutees. But the most surprising thing was to find an army of fitters working along the assembly lines; filing, chiselling and scraping seemed to be part of the accepted technique and it was obvious that as for the most part our productive labour was unskilled, we should have to approach the problem differently.
>
> "The first thing we did was to take every single production drawing and redimension it, not to increase the allowed tolerances but in most cases to tighten these up. If these vehicles were to be assembled at the rate of 50 or more per day by unskilled labour, it was obvious that the control of tolerances in production was such as to enable the parts to be assembled without fitting and that any one part was interchangeable with its counterpart.
>
> "On the machining side, although we used only standard machines, we tooled these in such a way that any operator after a few hours' training could produce parts to specification. Special fixtures and tools were designed and manufactured, gauges to set the tools were provided whenever necessary."
>
> (*Institution of Production Engineers Journal*, Vol. 34. No. 4.)

Action along these lines is the first step to ensure that the work is assembled in an orderly manner. Hold-ups due to faulty parts are more serious on line assembly than on batch assembly.

By ensuring that parts can be readily interchanged, the work of sub-assembly will benefit. This ensures a regular flow of units to the line assembly stage. Some components, however, are made to such close tolerances that it is no longer possible to obtain this interchangeability under normal manufacturing conditions. In these instances, the practice has been for the fitter to rely on a selective assembly to achieve the required fits between the components.

This type of selective assembly must be eliminated from any line assembly set-up. It will be necessary, therefore, to grade these parts within the manufacturing tolerances or "pair" any items that come in this category before issuing them to line assembly.

Having obtained interchangeability, not only will assembly benefit, but it will greatly assist maintaining the product in the field. Sir Leonard Lord stated how necessary this was in the car industry. Mr. Martin confirms that it is also necessary in the machine tool industry.

storage after machining and issue of parts to assembly

building "unit" stores with pallets; parts issue trolley for assembly section

In his Paper on "Investigating In Better Materials Handling", Mr. K. Trickett, B.Sc.(Eng.),

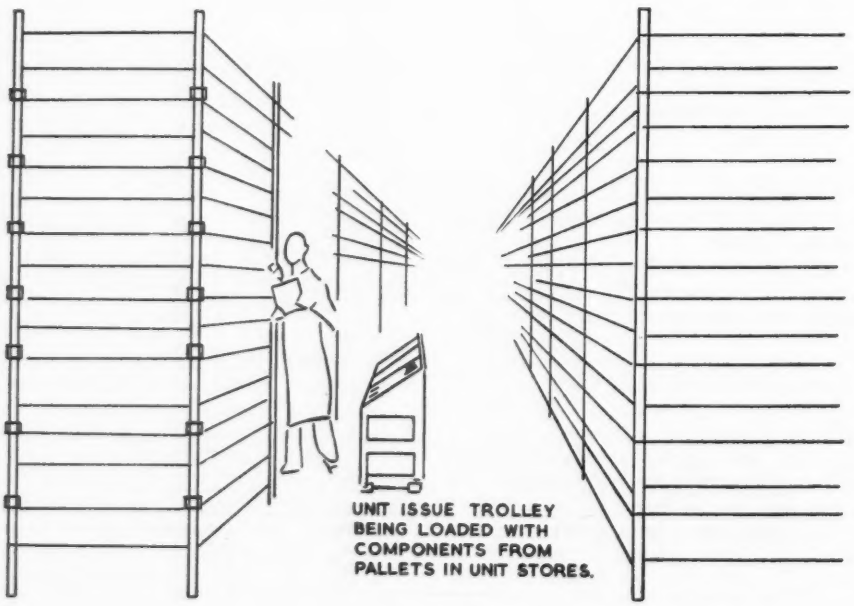


Fig. 2.

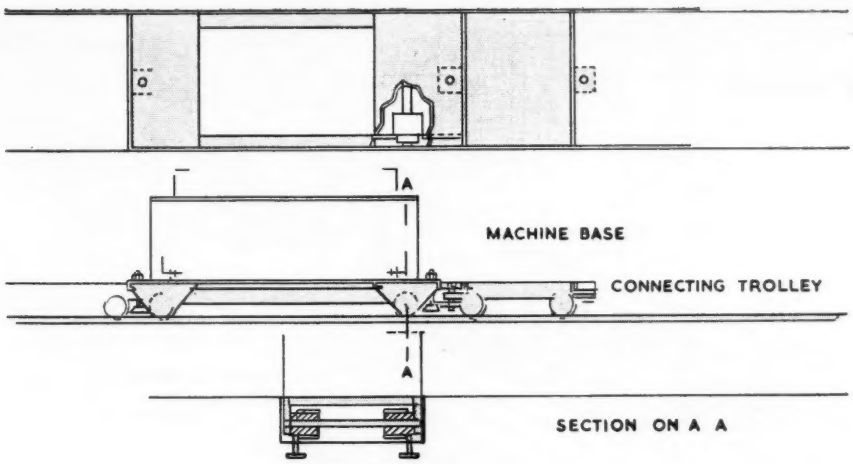


Fig. 4.

A.M.I.Mech.E., had this to say about the assembly shops . . .

> "In assembly shops again, the various operations are almost entirely handling, but unfortunately these jobs frequently receive insufficient attention from the Planning Department. One often finds very detailed and complete operation layouts drawn up for machining and process operations, but if a layout for assembly is issued at all, it carries only the bald instruction 'assemble complete' and in the column headed 'Tools' the ubiquitous word 'Miscellaneous'. The assembly shop is therefore often a very fertile field for the materials handling engineer and marked improvements can usually be made."
>
> (*The Institution of Production Engineers Journal*, Vol. 35, No. 9.)

How, therefore, can a Materials Handling Engineer help partial line assembly? Firstly, by seeing that parts are stored under an appropriate unit. For example, all parts necessary to build a complete gearbox will be kept in the Stores under say, Unit 6 Gearbox. A suggested method of storage is by building up sections with standard pallets.

Secondly, by providing unit trolleys that contain complete sets of parts. These trolleys should be designed so that there is a place for everything and a glance would reveal that everything was in its place.

When an issue of parts is to be made to assembly, the unit trolley is wheeled along to the unit storage area and the parts loaded on to the trolley. It is then placed in position on the shop floor (Fig. 3).

proposed application of "partial" line assembly to produce 30mm. bar capacity single spindle automatics at the rate of 10 machines per week

(design of track and trolleys; method of propulsion; rate of movement)

There are two factors which must be given consideration when designing a track. The first is the weight and dimension of machine. The second is the rate of production required.

The dimension and weight of the machine enables us to establish the strength of the materials used for the track. By considering the rate of production required and the work content of each machine, the length of track can also be calculated.

Care must be taken, however, when the track has to be designed for more than one type of machine. It will then be necessary to consider the size and weight of the largest one when calculating the strength of the materials.

Consider, for example, a machine weighing two tons and having overall dimensions 6 ft. × 3 ft. Two inverted "T" section angle iron pieces should be set in the floor of the assembly shop to stand up $\frac{5}{8}$ in. from the lower level. These will give $\frac{1}{8}$ in. ground clearance to the wide portion of trolley wheels (Fig. 4).

The track itself should be laid below the general level of the floor, in order to compensate for the height of the trolleys used to convey the machine along the track at ground level.

By having the machine at this level, we eliminate most of the stretching during building. It also means that we will have no rails or trolleys to trip over when walking between the machines. Assembly fixtures used to position, say, the main drive unit, can

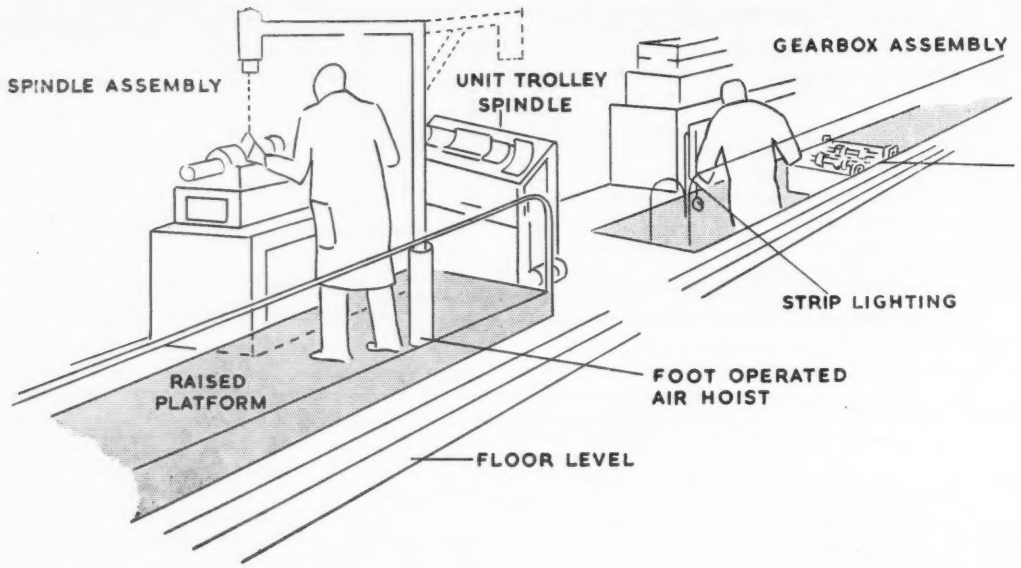


Fig. 5.

be wheeled along at floor level and offered up to the machine at the correct height.

Moving the machine with its base at floor level will ensure that the majority of workers are able to carry out their jobs at the correct level. Most machines are designed to be at the right level for operating when in this position. However, when this condition cannot be obtained it will be necessary to raise or lower the part of the floor on which the fitter stands (Figs. 5 and 6).

Trolleys are constructed of angle iron frames with plates welded to each end to give rigidity and a large mounting surface for the machine. The wheels are mounted on axles inside the frames and are designed so that they will run on the wide portion on the floor of the assembly shop, and engage on the rails by the small shoulder at the start of the line.

Connecting trolleys are used to join the main ones together. This allows a space between the machines to carry out the assembly of end mounted units, such as the main drive or electric motor.

A suggested method of propulsion for the trolleys is to use an overhead crane to pull up a wire running under the pulley. This pulley is designed to drop into the floor when not in use. An alternative can be an electric motor with reduction gear winding up a drum, in turn pulling the train of trolleys along (Fig. 7).

The machines will be moved in accordance with the rate of production required and the number of stages.

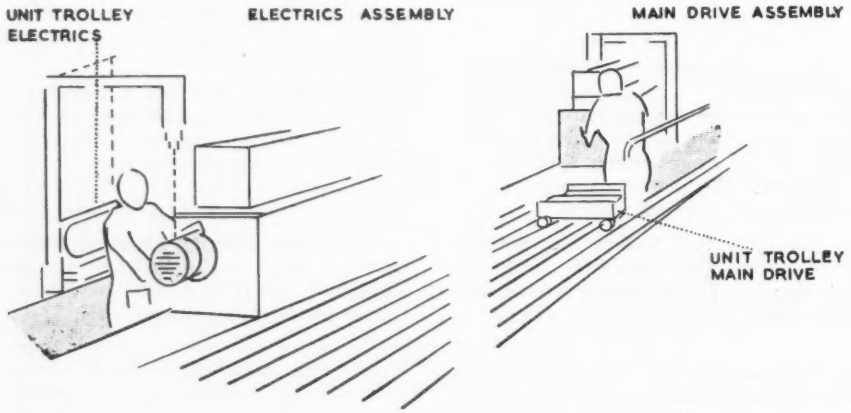


Fig. 6.

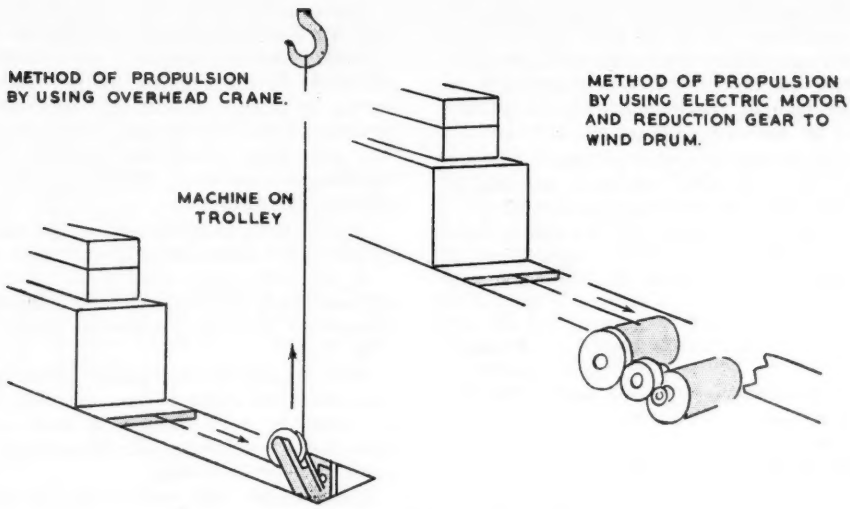


Fig. 7.

proposed layout for assembly line stages

We have arrived at our starting and finishing points in accordance with the considerations in the section: "Anti/Post Line Operations". It is now necessary to find the best sequence in which to complete the intermediate line assembly operations.

The assembly line must now be split into various stations where work will be carried out. The layout of these stages will be determined by the rate of production required and the number of man hours entailed in the "fit to machine" operations.

For example, in the assembly of single spindle automatics, at the rate of 10 machines per week with a "fit to machine" time of 40 hours each, a total of 400 man hours will be required each week.

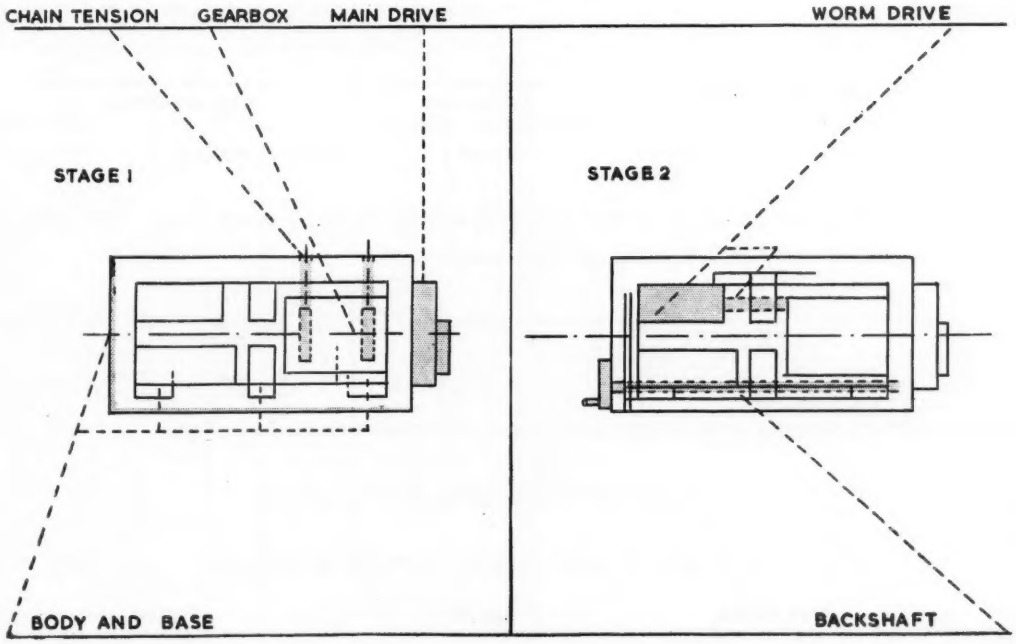


Fig. 8.

This total will be achieved by 10 men working on a 40 hour week basis. These 10 men will have to produce at the rate of two machines per eight hour day. Therefore, the number of daily stages will be five, with two men at each stage and two of the machines will be moved up one stage each day.

Having established these figures it is then necessary to list all the "fit to machine" elements in a logical order and select those jobs that can be carried out at one of the several stages*. These jobs can then be used to balance the work content to the target figure of eight hours work per machine per day on each of the five sections;

Logical Order of Assy.	*Assy. Op.*	*Assy. Time in Hours*	*Assy. Stage*	*Revised Order of Assy.*
1	Body, base	4	1	1
2	Gearbox	1	1	2
3	Main drive	2	1	3
4	Worm drive	4	2	5
5	Backshaft	4	2	6
6	Chain tension	1*	1	4
7	Cross slides	4	3	7
8	Spindles	2	3	8
9	Lubrication	4	4	10
10	Turret	2*	3	9
11	Guards	4	4	11
12	Electrics	8	5	12

The first of the line assembly stages will consist of the body and base, gearbox, main drive and chain tension. The chain tension moved from No. 6 is in the logical order of assembly, up to No. 4 in the revised order to give a balanced load of eight hours for Stage 1 (Fig. 8).

The gearbox being situated well below the waistline of a fitter standing on the floor of the shop, it is necessary here to construct a pit in which the worker stands to fit the gearbox to the machine. The pit should be fitted out with lighting arrangements and provision made for the unit trolley for gearbox parts. The main drive unit is also fitted into the end of the machine at a low level; therefore, a lowered assembly position is required.

As illustrated in the schedule the worm drive and backshaft are assembled at the second stage (Fig. 8).

At the third stage, cross slide, spindles and turret are assembled. The order for the completion of turret changes to No. 9 to balance the load of eight hours (Fig. 9).

With regard to the spindle assembly, this would necessitate stretching if the machine and the fitter are both at floor level. The area in which the operation is carried out should be raised to bring the work to a suitable height.

Sub-assembly unit trolleys should be designed to present the parts to the fitter at the most convenient height.

To facilitate the handling of heavier sub-assemblies, a foot-operated air hoist can be installed at suitable points along the line.

During the fourth stage, all guards are fitted and all piping for lubrication is fitted.

At the fifth and final stage, we have two men engaged in fitting electrics. Here again, the problem of fitting the electric motor is somewhat similar to that of the main drive, therefore, a lowered stage is again necessary (Fig. 9).

The final inspection on the machine, before passing to running test, is carried out at the end of the line.

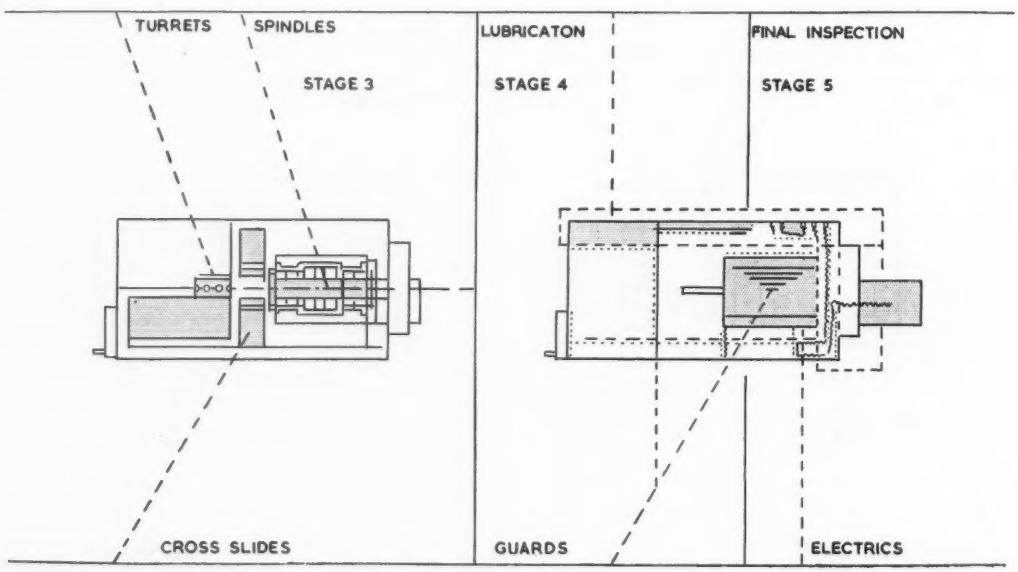


Fig. 9.

conclusion

Partial line assembly reduces costs on the shop floor by bringing the job to the man and reducing the walking about for tools and materials, always present on the batch methods.

Some batch schemes are based on a method that involves one or two highly skilled fitters being responsible for the complete build of a machine. This method not only calls for a very high all-round skill, it also means that for certain unskilled or semi-skilled operations, the wrong grade of labour is being used.

Line assembly enables a high degree of specialisation to be developed and ensures that skills are put to proper use at all time. This specialisation and breakdown of jobs enables new labour to be trained quickly and effectively.

The provision of fixed stages on a line enables the use of special jigs, tools and power driven devices to be fully exploited. With a place for everything and everything in its place, searching for tools is eliminated.

With regard to component parts, the same remarks apply. The provision of unit trolleys means an end to parts "lost on section" and makes easy the job of checking and issuing from stores.

It also ensures that special provision is made for protecting fragile components during transit on the shop floor.

Moving the train of machines at fixed intervals has the effect of setting a daily output target. Having established labour standards by work study, this movement can be used as the basis for group incentive and is much more effective as a visual check than figures on a board recording output.

Visual indication of progress can be extended to the Manager's office, by using light signals operated by trolleys, once again to bring the job to the man. Although indicators on the wall will never tell the same story as a walk down the shop, they will show how things are going, and ensure that "management by exception" goes into action immediately things go wrong.

A partial line assembly scheme will, by the proper layout of the place of work and the placing of tools and materials, largely eliminate the time and energy spent in bending, stretching, fetching and carrying, made necessary by batch assembly methods.

It will ensure that full use is made of every minute a worker spends on the shop floor, and that skills are properly utilised.

In addition to these improvements in labour utilisation, this scheme will ensure that the most effective use is made of available floor space.

DIARY DATES FOR 1959

June 18th - 19th ... Conference on **"Quality in Industry"**, Palace Hotel, Buxton. (See Supplement to this Journal.)

August 26th - 30th ... **Summer School, Ashorne Hill.** (See Supplement to this Journal.)
Theme: **"Management Staff Education, Selection and Training."**

September 24th - 25th **Eastern Regional Conference, Norwich.** (See Supplement to this Journal.)

October 12th ... ... **The 1959 E. W. Hancock Paper,** to be presented in Bristol.
Speaker: **Mr. R. A. Banks,** Personnel Director, Imperial Chemical Industries Limited.
Subject: **"Human Relations in Industry."**

November 19th ... **The Annual Dinner,** Dorchester Hotel, London, W.1.

"TOOL WEAR AND MACHINABILITY"

From : **Mr. S. Kumar, Grad.I.Prod.E.,**
Research Division,
Brush Electrical Engineering Co. Ltd.,
Loughborough.

DR. Trent's Paper on "Tool Wear and Machinability", published in the March issue of the Journal, presents very useful information on tool wear, and should be of interest to production and research engineers working on problems allied to metal cutting.

The formation of built-up edge and its effect on surface quality and tool wear are qualitatively well known. The disappearance of built-up edge at high speeds has been generally observed. However, in order to appreciate the stability of this build-up more clearly, it is desirable to study the mechanics of chip formation; the type and manner in which the rupture is brought about to separate the chip from the parent metal.

It has been observed that the built-up edge is also absent at very slow speeds (discontinuous type chip formation), and because of this often a better surface finish can be obtained by using a very slow cutting speed. The shear type chip is accompanied with a built-up edge at comparatively slower speeds, finally disappearing as the cutting speed is increased.

At the end of the Paper it has been mentioned that an investigation into the influence of top rake will be very valuable. It is difficult to disagree at this point.

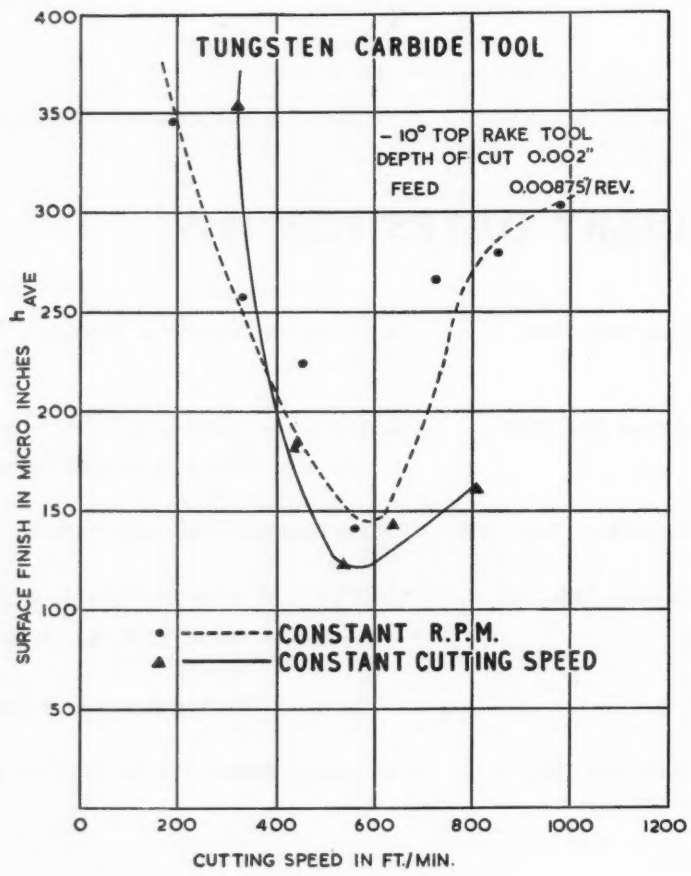
The use of negative rake tools has been found promising at high speeds. The reduction in tool forces will result in reduced crater wear. However, the increased chip tool interface temperature may contribute to serious deformation. An effective use of coolant may provide an answer. The use of ceramic tool materials will make it possible to use much higher cutting speeds.

Experiments conducted to investigate the effect of speed and top rake on surface quality have shown that the quality improves with the increase of speed, finally becoming asymptotic to the ideal surface finish, depending upon the geometry of the tool.

The results obtained by the writer while cutting mild steel with high negative rake carbide tools showed that deteriorated finish results, as the speed is increased beyond a certain optimum *. (See graph below.)

Looking at the magnified surface records it was found that although the surface finish ("h" average) had deteriorated, the feed marks were smoother than

* KUMAR, S. "Investigation into the Effect of Using Constant Cutting Speed During Facing Operations on a Centre Lathe." M.Sc.Tech. Thesis, 1957.



at lower speeds. This can, perhaps, be attributed to the effect of built-up edge. A small built-up-edge formation may remove the edges that join the feed marks, thus giving a better "h" average value.

The possibility, however, cannot be excluded that at higher speeds (1,000 ft./min. used in the mentioned test), better finish will result.

It will be of great value to investigate the tool wear of negative rake tools. Such tools have been found to result in reduced cutting forces and better surface quality at high speeds.

Dr. Trent replies:

IT is interesting to note from the data given by Mr. Kumar that it is possible for an actual improvement in measured surface finish to be recorded due to the presence of a small built-up edge. While this information is of interest in itself, it would be of greater value in helping to piece together a general theory of machining if more of the relevant data were given. For example, where the depth of cut is as small as .002 in., the precise shape of the nose of the tool is more important than the top rake in relation to surface finish. It would be useful also to know the condition of the tool after the test and what class of carbide tool was evolved, since this is very relevant to the built-up edge.

Mr. Kumar mentions the absence of a built-up edge at very low speeds. In my work cutting speeds much lower than 40 ft./min. have not been used, nor have high top rakes or cutting lubricants in most cases, so that only in the case of high sulphur steels (Figs. 30 and 31 in the Paper) was a lower limit found to the occurrence of the built-up edge. It would require systematic research on many different work materials at low speeds with varying top rake and cutting lubricants to determine the range of conditions in which the built-up edge is absent. Without this work I would not be prepared to say whether a built-up edge is always absent at very low speeds but, in view of results on the high sulphur steels, I would expect the lower limit to the occurrence of the built-up edge to be a function of both speed and feed. A systematic programme of research on this subject is needed and would be very rewarding.

With regard to the use of negative rake tools at high speeds, it would be interesting to have Mr. Kumar's data showing the reduction of tool forces. While most published data show reduced tool forces with increased cutting speed, generally they also show the cutting force to be higher with negative than with positive rake. It does not follow that reduced cutting force results in reduced crater wear. While cutting force drops with increasing speed, the rate of cratering increases and our knowledge of the cratering process suggests that it is the interface temperature, rather than the cutting force, which controls the rate of cratering. As normally applied, coolants are unlikely to have any appreciable effect on high speed cratering wear, since they cannot prevent the heat being generated at the interface. It seems doubtful whether any method of applying a coolant could greatly affect this form of wear.

INSTITUTION AWARDS

From: **Mr. Peter Spear, Grad.I.Prod.E.,**
Director of Research,
Rubery, Owen Ltd.

I HAVE read with particular interest the report of the Papers Committee in the Chairman of Council's report published in the January Journal, and I am greatly disturbed to note that in the last two years it has not been possible to award the Hutchinson Memorial Award because of the paucity of Papers.

This particularly concerns me since it so happens that I had the honour of being awarded this Medal in 1948, and at the same time the Award for the best Paper of the year by any grade of member. As far as I am concerned personally, it marked quite a turning point in my career, and hence I feel the importance of other younger members taking advantage of the opportunities available.

At one time I was associated with the Birmingham Graduate Section Committee and we went to very great efforts to persuade Graduates to present Papers. Indeed, in one year we managed to get three, at least one of which was published. My personal experience has been that there are plenty of younger members who can present very useful Papers. Often they forget that what might be fairly common to them (and consequently they are diffident to present) in their particular aspect of industry is quite new and quite useful to other members in other industries. One of the chief difficulties is that they are worried about the sheer mechanics of presenting a Paper. With a little bit of advice about layout, assistance in typing, preparation of slides and other illustrations, etc., they can soon be coaxed along. At one time in Birmingham we used to have a small sub-committee of Graduates who had gone through the struggle and who gave advice to others. This worked quite well.

Some time ago I prepared a report for the Editorial Committee, which was fairly well circularised, suggesting methods of increasing the effort to make the younger members present Papers and give lectures. Some action has been taken but it is quite obvious that a lot more can still be done to encourage the younger members of our profession and to ensure that they realise that the personal effort in preparation and delivery is a very important part of their general training.

I would like to stress that this letter is written in a spirit of helpfulness. Many of my colleagues know that I have been both agitating and working in a practical manner for some time to encourage the younger fellow members along these lines. Indeed, when one sits on some committees and realises how difficult it is at times to get people to come forward and present Papers, many of the above remarks might also apply to the older members as well.

Schofield Travel Scholarship

SPECIAL ANNOUNCEMENT TO ALL GRADUATE MEMBERS OF THE INSTITUTION WITHIN THE UNITED KINGDOM

AT a meeting of Council held on 30th April, 1959, it was agreed that in future the Schofield Travel Scholarship should be of the value of £500 per award, or in special cases up to £750.

Forms of application and full details are obtainable from the Registrar of the Institution, and applications for this year's award must be received by **30th June, 1959.**

PETERBOROUGH PRESENTATION

The informal Dinner Party given by the Peterborough Section Chairman, Mr. H. B. Harris, on 13th March last, was also the occasion of a most generous presentation by the firm of Baker Perkins Ltd., of Peterborough. This took the form of a medallion to be worn by the present and all future Chairmen of the Section during their terms of office. The design shows the Institution's crest, in colour, surrounded by the words "Peterborough Section Chairman", the whole medallion mounted on blue ribbon. In addition, three Past Section Chairmen were each presented with a small badge, of similar design.

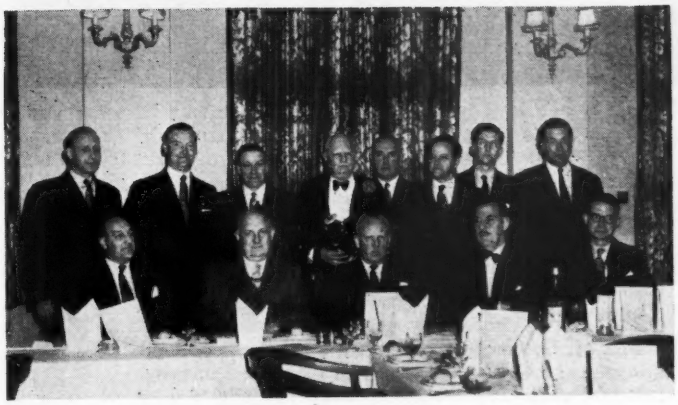
The photograph shows Mr. L. P. Simpson (left), Vice-Chairman of the Peterborough Section and Works Manager of Baker Perkins Ltd., making the presentation to Mr. H. B. Harris, on behalf of the Company.

LORD SEMPILL AT READING

The Chief Guest at the Reading Section Annual Dinner, held on 10th April last, was The Rt. Hon. the Lord Sempill, A.F.C., Hon.M.I.Prod.E., Past President of the Institution. Nearly 90 members and guests attended the function, which was as usual a most enjoyable occasion, excellent entertainment being provided.

The toast of "The Chairman and the Institution" was proposed by Lord Sempill, to which Mr. H. P. Mott, Chairman of the Section, replied. Mr. T. Christy proposed the toast to "The Guests", on whose behalf Mr. V. Lambert, C.B., C.B.E., responded.

On behalf of the Section Committee, Lord Sempill presented to Mr. R. Mark, Honorary Secretary, who is now relinquishing this office, a gift in appreciation of his past services.



The photograph above shows Lord Sempill (centre front) with other guests and members of the Section Committee. Mr. Mott, Section Chairman, is on Lord Sempill's left; and Mr. Mark, Honorary Secretary, is at the extreme left, back row.

WHITWORTH FELLOWSHIPS AND EXHIBITIONS

The Ministry of Education have announced that the value of the Whitworth Fellowship has been increased from £500 to £1,000 and that of the Whitworth Exhibition from £50 to £100. The award of Whitworth Prizes will be discontinued.

The new awards are available to British subjects over 25 years of age and holding a University degree in engineering; a Diploma in Technology (Eng.); a H.N. Diploma; or H.N.C. in Engineering with at least two distinctions. The field is limited to applications from serving engineers and at least three years as a practising engineer is required.

Full details of the awards are given in a booklet, "Rules and Conditions for the Award of Whitworth Fellowships and Exhibitions", which may be obtained from Her Majesty's Stationery Office, price 4d. net.

INCREASE IN DIP.TECH. STUDENTS

The number of students taking advance courses leading to the award of the new Diploma in Technology has increased more than two-and-a-half times during the past 18 months. In a foreword to the second report of the National Council of Technological Awards recently published, Lord Hives, the Chairman of the Council, says that 2,518 students are now following 66 courses leading to the Diploma at 20 colleges, as compared with 965 students following 37 courses at 11 colleges in November, 1957.

Since the Council was set up by the Minister of Education just over three years ago, the first Diplomas in Technology have been awarded and shortly several hundred diplomats will be taking their place in industry each year. The Council express their great indebtedness to the technical colleges and to the industrial organisations whose effects have made possible "this rapid and striking development". Lord Hives, in paying his tribute to industry, refers to the fact that 82% of students following sandwich courses leading to the Diploma in Technology have their fees paid by their employers.

Last November the Council outlined their plans for an award higher than a Diploma in Technology which would lead to admission to membership to the College of Technologists. This scheme is now well advanced and details will be announced as soon as possible.

The Institution of Production Engineers is represented on the Governing Body of the Council by Sir Walter Puckey, Past President, who is Chairman of the Board of Studies in Engineering.

MEMBERS TRAVELLING OUTSIDE THE U.K.

Members who are visiting Australia, New Zealand India, South Africa or Canada are reminded that the Institution has local Sections in these countries, where they will be made very welcome by the Institution's Honorary Officers and members there.

Papers on subjects of interest to production engineers and managers are always welcomed, and any members who are visiting one of the Sections outside the U.K., and who would like letters of introduction, should inform the Secretary of the Institution at 10 Chesterfield Street, Mayfair, London, W.1.

news of members

Mr. R. L. Aston, Member, has recently been appointed Head of the Department of Production Engineering, a new department, at Coventry's Lanchester College of Technology. Mr. Aston is a Corresponding Member of the Institution's Papers Committee.

Mr. H. G. Gregory, Member, has been appointed Director and General Manager of Fairey Engineering Ltd. following the reorganisation of The Fairey Aviation Co. Ltd. into a Holding Company with subsidiaries. Mr. Gregory, who has been managing the Northern activities of the Company since 1943, is Immediate Past Chairman of Council of the Institution, and a Past President of the Manchester Section. He has been a member of the Council for many years, and has also served on several of the Institution's Standing Committees.

Mr. T. E. Love, Member, has been awarded the Gloucestershire Engineering Society's highest honour of Life Member. Mr. Love was formerly Chief Engineer with Messrs. Williams and James (Engineers) Ltd. He is a Corresponding Member of the Institution's Papers Committee.

Mr. K. McMahon, Member, has been appointed to the board of the Hepworth and Grandage group of companies as Works Director. Mr. McMahon, who joined Hepworth and Grandage Ltd., in March, 1935, is a member of the Institution's Halifax Section Committee.

Mr. F. L. Andrews, Associate Member, has been appointed Works Director of The Coventry Victor Motor Co. Ltd., Coventry.

Mr. T. B. Brook, Associate Member, has taken up an appointment as Production Manager, Messrs. Richard Thomas & Baldwin Ltd., London Section.

Mr. N. E. Cornish, Associate Member, has relinquished his position as General Manager, W. H. Vowles & Sons Ltd., Stonehouse, Gloucester, to take up a full time appointment as a Director of L. W. Bailey & Partners Ltd., South Harrow.

Lt.-Col. A. E. G. Day, Associate Member, has recently been posted to Chepstow as the Chief Instructor for the fourth Army Apprentice School which will be opened in January, 1960.

Mr. J. France, Associate Member, has been appointed Senior Technical Representative for the Yorkshire and North East area of Dean Smith & Grace Ltd. He has been with the Company since 1953 in the position of Technical Representative.

Mr. R. W. Marston, Associate Member, has been appointed a Director of J. Parkinson & Son (Shipley) Ltd.

Mr. R. A. Powell, Associate Member, has relinquished his appointment as the Assistant Production Engineer with the Western Division of Bristol Aircraft Ltd., and has joined H. H. Fraser and Associates (Rhod.) (Pvt.) Ltd., Industrial Consultants of Bulawayo and Johannesburg. Mr. Powell is currently resident in South Wales, having joined a team of Fraser Engineers carrying out an assignment there.

Mr. N. L. Akerman, Associate Member, has been appointed Sales Manager of Dean, Smith & Grace Ltd. He has been with the Company since 1953, in the position of Senior Technical Representative for the Yorkshire and North East area.

Mr. C. Bradley, Graduate, has taken up an appointment as Senior Methods Engineer, at Marconi Wireless & Telegraph Co. Ltd., Chelmsford.

Mr. F. E. Newton, Graduate, is now a Welding Engineer at Fisher & Ludlow Ltd., Birmingham.

Mr. K. D. Smith, Graduate, has recently taken up an appointment as Divisional Engineer (Engineer II), Nuclear Physics Division, A.E.R.E., Harwell.

Mr. P. Stewart, Graduate, has relinquished his position with George Swift & Sons Ltd., Halifax, and has taken up the position of Cost Control Manager with W. & S. Summerscales Ltd., Keighley.

Mr. W. G. Whiteley, Graduate, has recently relinquished his position with Rotax Limited, and has taken up an appointment with Metropolitan Vickers Electrical Co. Ltd., Trafford Park, Manchester.

GROUP PROVIDENT SCHEME

THE Institution has a Provident Scheme for its members in the U.K. The object is to safeguard members against the expense of private treatment for major illnesses, including surgical operations. Private treatment in nursing homes, hospital pay-beds and private specialists' consulting fees, do not come under the National Health Service, and the patient has to pay the full cost. The Provident Scheme is designed to enable members of the Institution, and their dependents, to make the best and speediest arrangements without having to worry about the cost, and to provide a measure of privacy during treatment which is not possible under the National Health Service. Thus the Scheme is not intended to displace the National Health Service, but to provide supplementary benefits.

Under the Institution's Group Provident Scheme, the British United Provident Association's standard rates of subscriptions are reduced by 20% and arrangements are made for the collection of subscriptions annually by Banker's Order made payable to the Institution. Members are entitled to benefit immediately on acceptance and are not subject to the usual three monthly waiting period.

If you are already a private member of the B.U.P.A. and under 65 years of age, you can apply to transfer to the Institution's Group Scheme and get the benefit of 20% reduction in fees. A refund of any balance of your current individual subscription which may be outstanding, would be made.

Members interested in joining this Group Scheme are asked to write to the Secretary of the Institution, asking for full details and an application form.

CORRESPONDENCE TO HEAD OFFICE

There have been quite a number of instances where post intended for Head Office has been delayed, due to the fact that the envelopes have not been clearly addressed, and it may also be assumed that, for the same reason, a number of letters do not reach this office at all.

There are quite a number of places in London which include the name "Chesterfield" in their address, for example, Chesterfield Gardens, W.1., Chesterfield Road, W.4, etc. Delivery of correspondence to Headquarters can only be guaranteed if the envelope, or other package, is accurately addressed. The word "Street" must be written in full, as the abbreviation "St.", when in manuscript is frequently — and understandably — read as "Sq." or "Pl.", and is delivered accordingly with consequent delay. In order to help overcome this problem, it is intended in future, to include the word "Mayfair" in the Institution's address.

Any mail being sent to the Institution must be addressed as follows:-

THE INSTITUTION OF PRODUCTION ENGINEERS,
10 CHESTERFIELD STREET,
MAYFAIR, LONDON, W.1.

JOURNAL BINDERS

The increased size of the Journal has made impractical the present type of binder, and as a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six Journals.

It will be found that copies of the Journal can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference, and handling of the volumes.

The new binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF ENGINEERING PRODUCTION

Applications are invited for admission to the following one-year postgraduate courses in October, 1959.

Master of Science Course in Engineering Production ***(in the case of non-graduates this course leads to the Diploma in the Principles of Engineering Production and Management)***

The primary object of this course, which is now in its tenth year, is to provide advanced education and training for engineering graduates and others with equivalent qualifications, who have had a minimum of two years' industrial experience.

Course members are required to undertake laboratory and industrial case study work in addition to attending lectures and tutorials in the following subjects :-

Production Management	Production Technology
Productivity Measurement	Product Design and Process Planning
Work Study	Plant Layout and Materials Handling
Applied Statistics	Production Planning and Control

Approximately one-third of the year is devoted to an individual project or investigation leading to the preparation of a report or minor thesis.

Master of Science Course in Operational Research

The object of this course, which was introduced last session, is to provide advanced education and training for honours graduates in Science or Mathematics, who have already had a minimum of two years' industrial experience and who intend to take up careers in Operational Research in industry. The main subjects are :-

Principles of Engineering Production	Work Study
Mathematical Statistics	Analogue and Digital Computers
Operational Research Techniques	Productivity Measurement

Each course member is required to undertake an investigation of a practical industrial problem and to submit a report for examination. Co-operation of industrial companies is sought in the selection of suitable problems and in the provision of facilities for study.

Admission to the above courses is limited to a maximum of 20 Engineering Production students and six Operational Research students. Most of those attending are normally sponsored by industrial companies, although funds are available to maintain a small number of independent candidates. The Department of Scientific and Industrial Research has accepted these courses as suitable for the tenure of its Advanced Course Studentships.

Further information may be obtained from :-

PROFESSOR N. A. DUDLEY, Ph.D., M.I.Prod.E.,
HEAD OF THE DEPARTMENT OF ENGINEERING PRODUCTION,
UNIVERSITY,
BIRMINGHAM, 15.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

> "The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

Bethel, Lawrence L., and others. **"Essentials of Industrial Management"** by Lawrence L. Bethel, Franklin S. Atwater, George H. E. Smith and Harvey A. Stackman, Jr. 2nd edition. *London, New York, etc., McGraw-Hill,* 1959. 514 *pages. Illustrated. Diagrams.* 50s.

The first edition of this book was published in 1954. "Some of the new emphases in this edition are recent developments in trends towards integration of companies; new refinements in the decentralisation of management functions; developments in automation and operations research; new Government regulations and practices pertaining to marketing, industrial relations, taxation and finance (i.e., U.S.A. Government regulations) — Emerging problems in labour relations and collective bargaining — New steps in the application of electronics to plant and office operations; and the new problems, policies and practices growing out of a strongly competitive 'buyer's market'." Contents: The industrial organisation; its nature and structure — Industrial enterprise and the pattern of economic activities — Industrial finance, risk and insurance — Developing and engineering the product — Physical facilities; the plant and equipment — Physical facilities; plant layout, materials handling and automation — Methods analysis and control — Materials control — Production control; routing and scheduling — Production control; dispatching and follow-up — Quality control — Principles of industrial relations — Administration of industrial relations functions — Wage and salary administration — Sales and advertising — Financial controls — Office management — Co-ordinating the enterprise — Bibliography — List of films and other visual aids..

Bowman, Edward H., and Fetter, Robert B. (editors). **"Analyses of Industrial Operations."** *Homewood, Ill., Richard D. Irwin,* 1959. 484 *pages. Diagrams.* $7.95.

Interest in operational research for the analysis of industrial operating problems of management is growing. This collection of papers includes material which has for some years been used as a graduate course in M.I.T.'s Graduate School of Industrial Management. While the book should help industrial and academic students to understand the methods of analysis available, it is primarily concerned with the problems of their application, and is essentially a series of analyses and solutions of industrial problems. There are four sections: Applications of linear programming (e.g., Warehousing and distribution of a seasonal product; A problem of optimal machine loading) — Other programming operations (e.g., Production control) — Waiting line application (e.g., A congestion problem in an aircraft factory) — Applications of incremental analysis (e.g., Marginal analysis, multi-plant firms and business practice) — Total cost and value models (e.g., Economic equipment policies). There are 26 studies.

British Steel Founders Association, Sheffield. **"Foundry Steels and their Applications."** *Sheffield, the Association,* 1958 ? 23 *pages. Illustrated.*

Campbell, Donald P. **"Process Dynamics: Dynamic Behaviour of the Production Process."** *New York, Wiley; London, Chapman and Hall,* 1958. 316 *pages. Diagrams.* 84s.

The author (the late Donald P. Campbell) was not satisfied with much of the work done in the process control field, because it was empirical, and was not founded on a sound theoretical basis. Even today engineers concentrating on controllers and other instruments fail to consider the plant as a whole, and install equipment to control part of a process, which would not be necessary if the plant and process had been considered as a whole. The design and development of process control systems must be put on a mathematical basis. Contents: Kinematics of materials handling — Fluids in motion — Forming, propulsion and guidance — Thermal process dynamics — Mass transfer dynamics — Chemical process dynamics — Problems — Block diagrams and signal flow diagrams — Fourier and La Place transformations.

Carr, Laurence H. A., and Wood, J. C. **"Patents for Engineers"** . . . being the substance of a course of lectures delivered at the Manchester College of Science and Technology. *London, Chapman and Hall,* 1959. 107 *pages.* 18s.

Contents: Outline of the British patent system — Legal aspects (1); Rights — Concerning patent specifications — Miscellaneous provisions — Legal aspects (2); Actions — Legal aspects (3); Kindred rights — Historic patents — Bibliography — Patent office fees chargeable at the date of this book going to press — Index of cases cited.

Central Youth Employment Executive. **"Engineering Work for Boys."** *London. H.M.S.O.,* 1958. 39 *pages. Illustrated. Diagrams.* 1s. 9d.

"Directory of Opportunities for School Leavers, 1959." *London, Cornmarket Press,* 1959. 188 *pages.* 8s. 6d.

Contents:
Editorial Section. The most difficult question — Where to get advice; people to see; books to read — Opportunities for girls in industry — The art of being interviewed — Going to a university — How to apply for a job; advice and specimen application — Chart; your future in industry — Technical training and apprenticeship — Going to school in industry — Careers in the professions — Nursing.
Reference Section. A wide selection of entries from companies and other organisations recruiting school leavers, in which they describe themselves, their work and the opportunities they offer — Classified index listing companies and other organisations under headings which they have selected to describe their activities, and giving other information in tabulated form for quick reference — Map showing locations referred to in the classified index with a list of counties in each area.

International University Contact for Management Education, Delft. **"Teachers in the Field of Management Education."** A list of titular members of the International University Contact for Management Education. *Delft, the Organisation, May,* 1958. 54 *pages.*

Joint Committee on Human Relations in Industry. **"Final Report of the Joint Committee on Human Relations in Industry, 1954 - 1957"** *and* **"Report of the Joint Committee on Individual Efficiency in Industry, 1953 - 1957."** *Department of Scientific and Industrial Research and Medical Research Council. London, H.M.S.O.,* 1958. 44 *pages.* 3s.

Ministry of Labour and National Service. **"Safety Devices for Hand and Foot Operated Presses."** *London, H.M.S.O.,* 1958. 32 *pages. Illustrated. Diagrams.* (Safety Health and Welfare — New Series.) 2s. 6d.

Ministry of Labour and National Service. **"Safety in Building Operations : Roofing."** *London, H.M.S.O.,* 1958. 12 *pages. Diagrams.* (Safety Health and Welfare — New Series.) 9d.

National Productivity Council, Delhi. **"Speaking of Productivity."** *Delhi, the Council,* 1958. 27 *pages. Illustrated.*

Oxley, A. **"Machine Shop Engineering Science for Craft Apprentices."** *London, Edward Arnold (Publishers) Ltd.,* 1959. 215 *pages. Diagrams.* 7s. 6d.

In his preface the author says: "My aim in writing this book is to encourage apprentice fitters and machinists to take a keener interest in the science of the workshop, by helping them to understand it more readily. Because of this, I am concerned mainly with the mechanics of machine tools, and to a lesser extent with other workshop processes. It is hoped that the book will be of special interest and use to students who are studying for the Intermediate Examination in Machine Shop Engineering of the City and Guilds of London Institute, and similar examinations of the Union of Lancashire and Cheshire Institutes and other examining bodies." Contents: Force. Stress — Moment of a force about a point. Turning moment. Torque — Work done by a force. Energy. Horse power. Efficiency — Belt and pulley speeds — Gear wheel speeds, gear trains, velocity ratios — Friction. Work done against friction. Power used in overcoming friction — Relationship between torque and horse power, torque and gear speed — Lifting machines. Mechanical advantage, velocity ratio, efficiency — Parallelogram and triangle of forces — Temperature. Heat, sensible heat, latent heat, specific heat, efficiency, relationship between heat energy and mechanical energy — Linear expansion. Coefficient of linear expansion — Revision exercises and answers.

P.E.P. (Political and Economic Planning), London. **"Graduates in British Industry."** The main findings of a study by P.E.P. *London, Department of Scientific and Industrial Research,* 1958. 28 *pages.*

Polytechnic Management Association, London. **"New Developments in Industrial Control."** Edited by Martin D. Callender. *London, Polytechnic Management Association,* 1958. 58 *pages.* 5s.

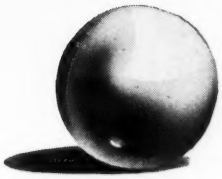
This book is one of a series based on revised and edited lectures delivered by people eminent in their respective fields to audiences of directors and senior executives at the Polytechnic, Regent Street, London. Contents: Introduction (John Ryan) — The economic forecasting approach (Eric Shankleman) — The management accounting approach (J. R. M. Simmons) — The statistical approach (E. D. Van Rest) — The personal approach (F. H. Perkins).

Technics and Purpose. **No. 5—"On Being a Technologist"** by D. G. Christopherson. 33 *pages.* **No. 6—"The Educated Man Today and Tomorrow"** by Sir John Wolfenden. 26 *pages. London, S.C.M. Press,* 1959. 2s. 6d. each.

The Technics and Purpose Series is sponsored by a working party convened by the Education Department of the British Council of Churches. It attempts to examine the issues arising in the growing importance of scientific techniques in our society, and the rapid expansion of technological and other education. The purposes and values involved are assessed in the light of the Christian faith. Doctor Christopherson, Professor of Applied Science at the Imperial College, assesses the responsibilities of the technologist in a technological society, and discusses the attitude of society as a whole to the technologist. Sir John Wolfenden, Vice-Chancellor of Reading University, discusses the nature and purpose of education, and the kind of education necessary in present and future society.

Whyte, William H. **"The Organisation Man."** *London, Cape,* 1957. 429 *pages.* 28s.

The "organisation men" are the American middle-class workers who staff all levels of executive and management in the great industrial organisations, banks and laboratories, and public utility undertakings still under private enterprise, who, through the influence of their purchasing power and social conscience, set the pace and temper of society. They are not white collar workers in the ordinary sense of the word. They not only work for the organisation; they belong to it as well. The organisation determines their social status, social customs and their ethics. The book is an examination of the structure and customs of this new type of social group, which, embryonic in this country, is, according to the author, highly developed in the United States.



HOFFMANN

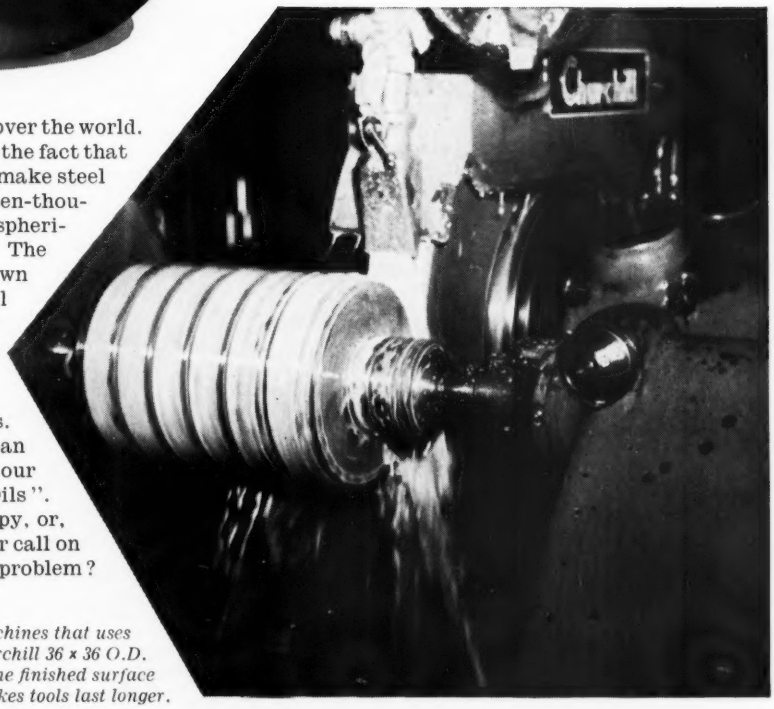
FAMOUS IN THE BALL-BEARING INDUSTRY DEPEND ON

DIXOL

SOLUBLE CUTTING OILS

HOFFMANN BALL BEARINGS are in use all over the world. Their standard of quality is typified by the fact that Hoffmann were the first in the world to make steel balls commercially, accurate to one ten-thousandth of an inch as to diameter and sphericity and of perfect mirror finish. The Hoffmann ball bearing outer races (shown at the right) between which the steel balls run, are accurate from −.0013″ to −.0018″.

To achieve such perfection and accuracy, these races are ground with the help of "DIXOL" Cutting Oils. Just how Wakefield-Dick lubricants can help your production is explained in our book "Cutting and Metalworking Oils". May we send you a complimentary copy, or, better still, may our technical engineer call on you for a talk on your particular problem?



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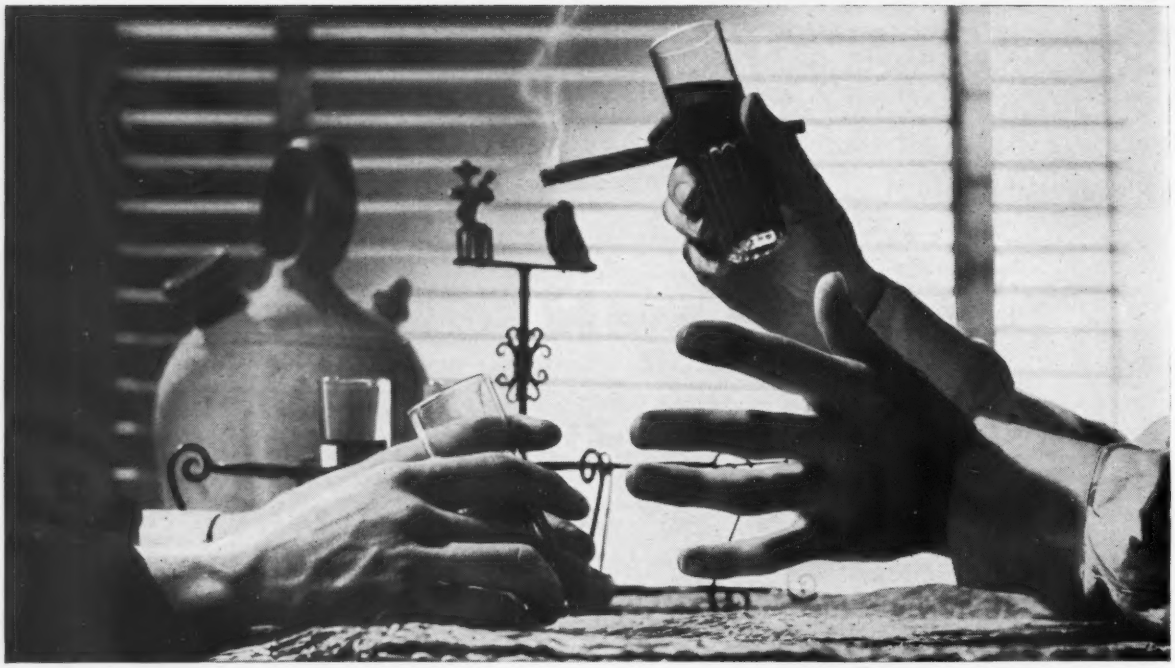

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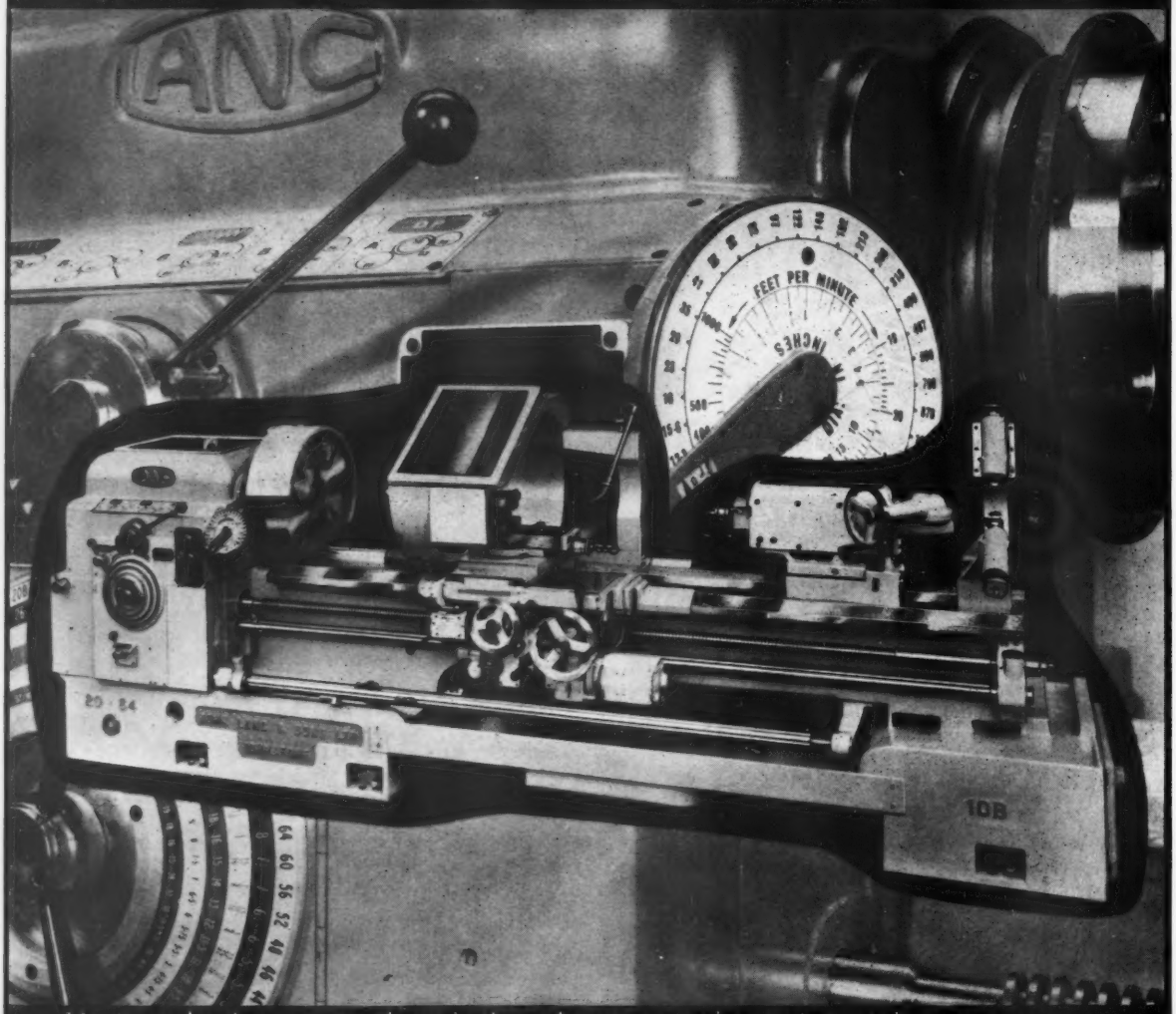

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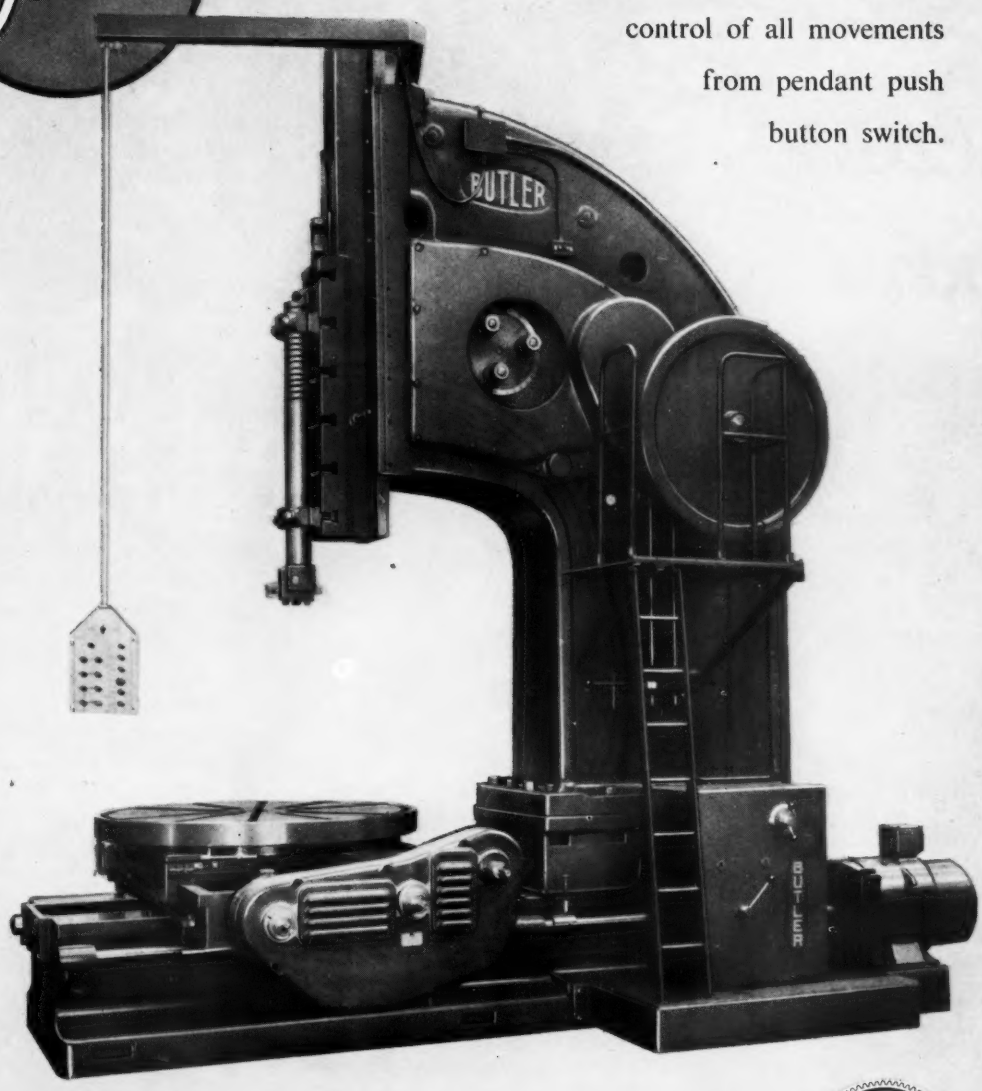

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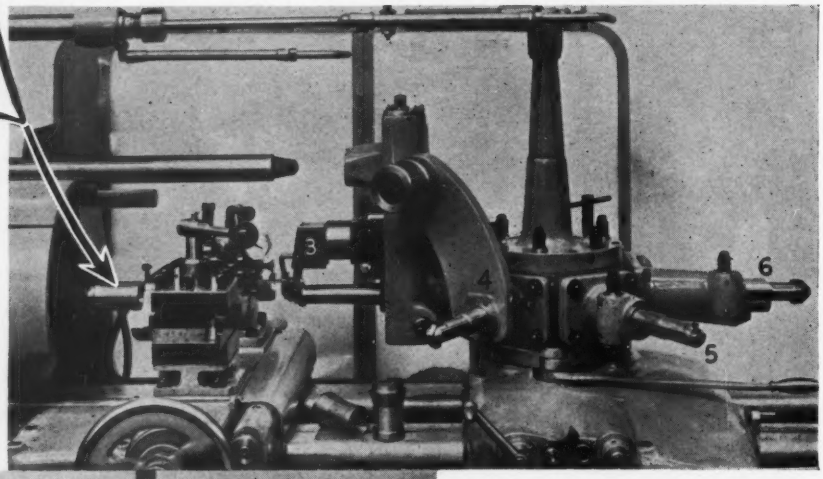

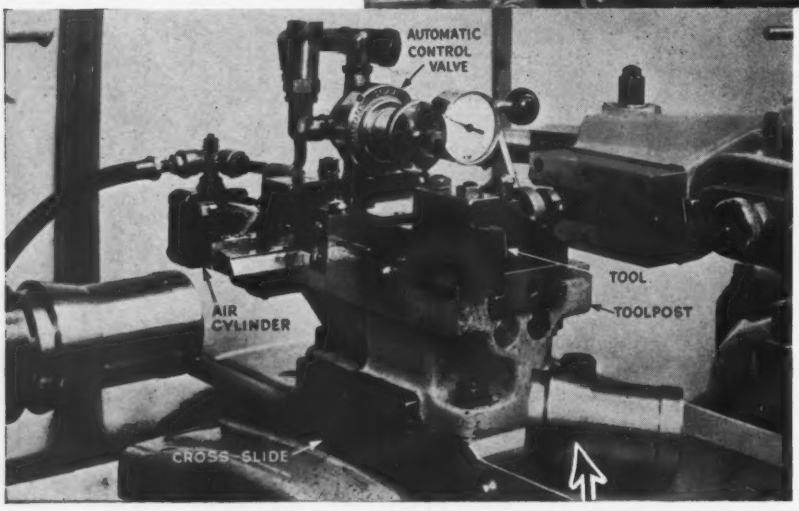

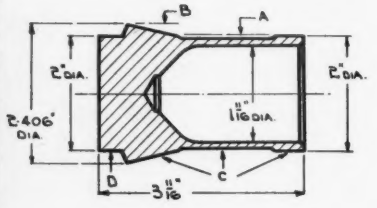

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12 mins. each.

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	Hex. Turret	Cross-slide			
1. Feed to Stop and Start Drill	1	—	350	—	Hand
2. Support and Rough Form Taper	2	Front 1	100	66	Hand
Rough Form Head	—	Front 2	100	66	Hand
Drill and Rough Knee Turn 2" dia.	3	—	200	161	266
4. Finish Turn and Face D	—	Front 3	700	440	Hand
5. Profile Turn C (Copy Attachment)	6	Rear	700	440	186
6. Rough Bore Bottom	4	—	170	75	Hand
7. Microbore 1 1/16" dia.	5	—	1000	442	266
8. Finish Bore Bottom, Face and Chamfer	6	—	70	30	Hand
9. Part Off	—	Front 4	240	126	Hand

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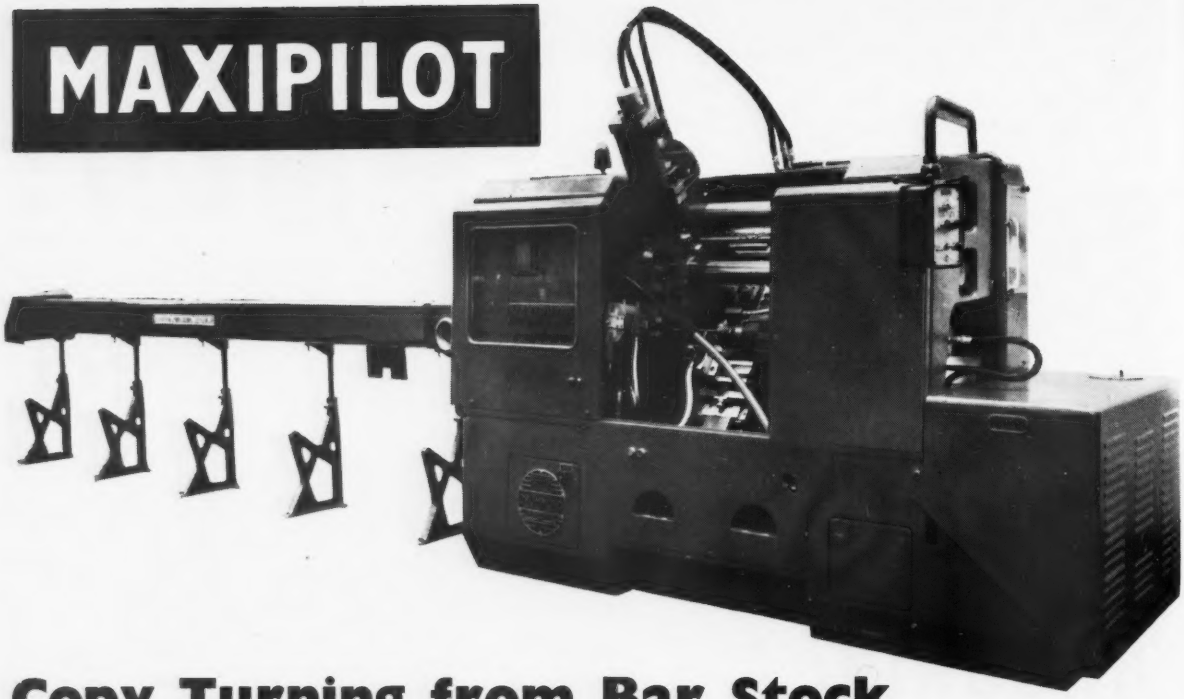
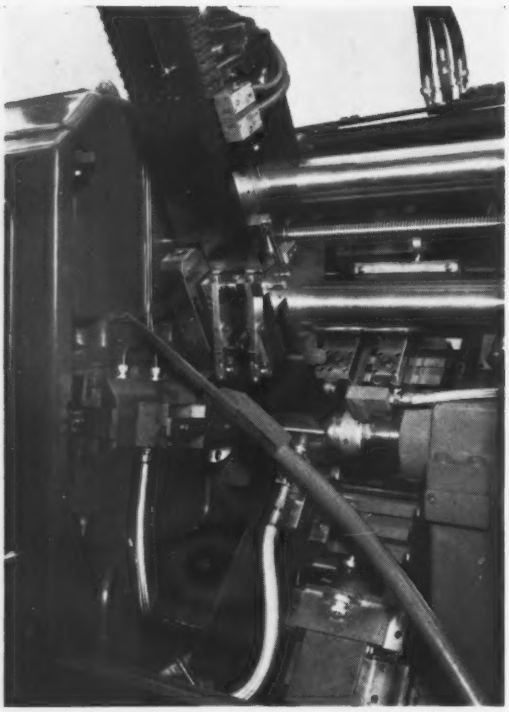


Copy Turning from Bar Stock



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This particular machine is arranged with stock carriage to accommodate 12—1 in. dia. bars or 24—$\frac{1}{2}$ in. dia. bars × 10 ft. 6 in. long. The basic "Maxipilot", however, accommodates work up to 9$\frac{1}{2}$ in. dia. over cross slide and 20 in. or 32 in. between centres.

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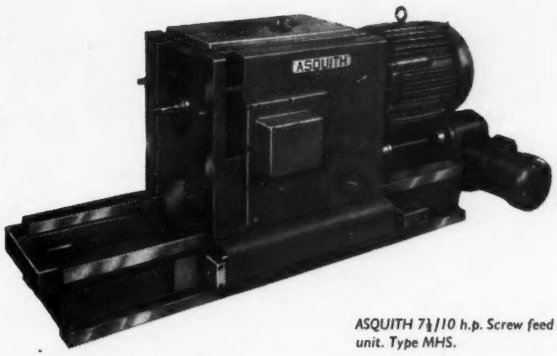

ASQUITH 7½/10 h.p. Screw feed unit. Type MHS.

The example illustrated is a five station, rotary table machine for drilling, reaming and milling operations on automobile spring hangers. A vertically mounted 7½ h.p. unit is arranged with the milling attachment and a 2 h.p. unit with multi-head and bush plate is also mounted on a vertical column. Another 2 h.p. screw unit operates horizontally. The 3 ft. dia. hand indexed table incorporates an air lift feature to reduce operation fatigue and clamping is automatic. The table is controlled by the foot valve at the base.

If you manufacture components in large quantities which require several machining operations, it will pay to investigate the possibility of producing them on an Asquith Unit Type Machine. Units from ½ h.p. upwards can be applied for multi-way, rotary transfer and in-line transfer operation.

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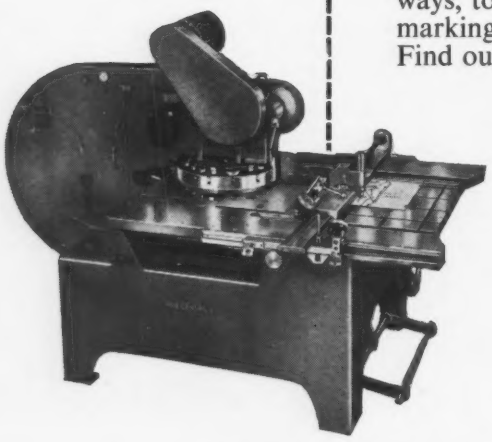

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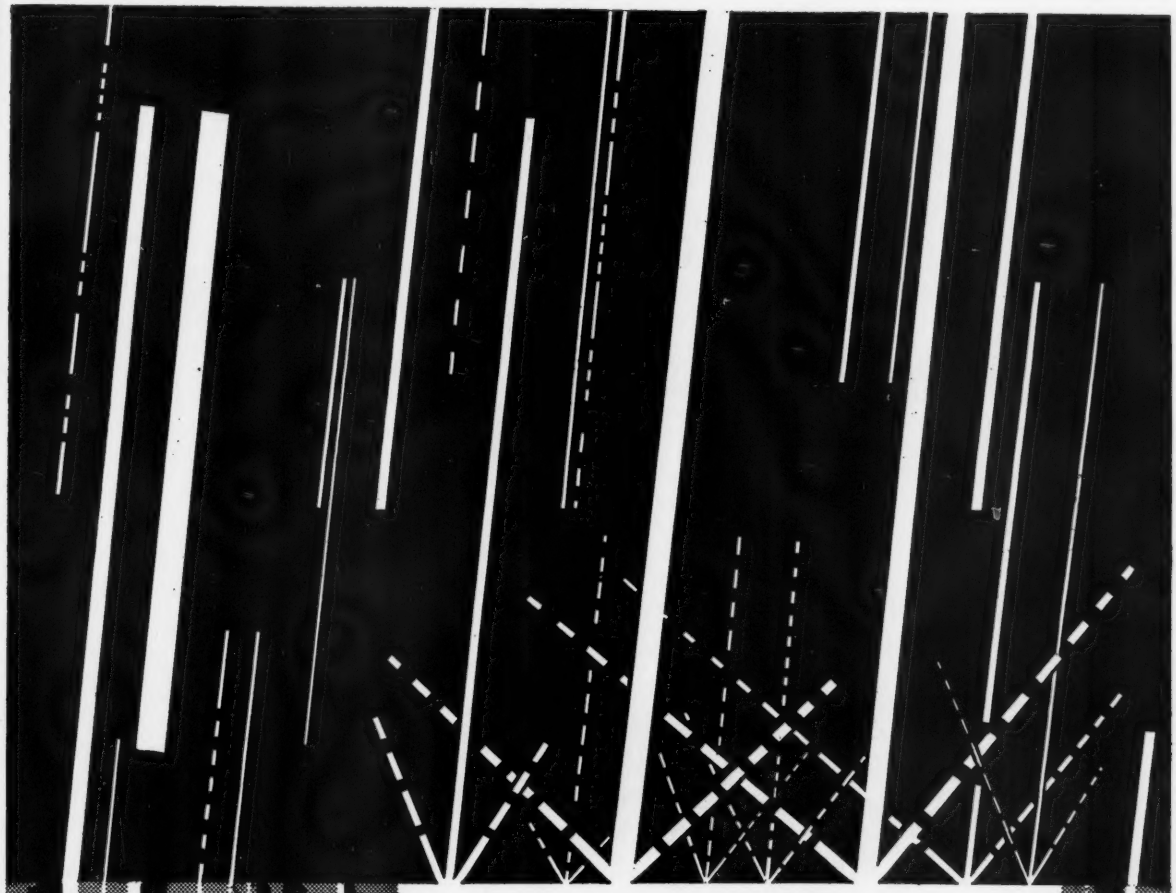

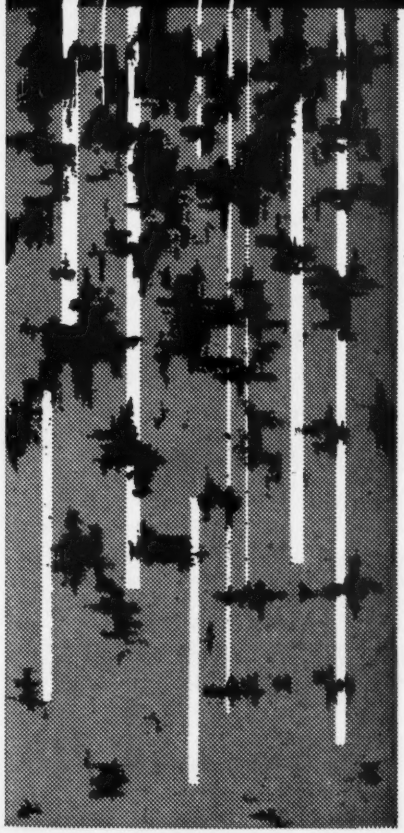

Water-repellency

Brush them on buildings and treat them to a monsoon downpour. Bake them into textiles and take them out in April showers. Spray them on leather and drag them through a puddle . . . and all the time they shed the water better than a duck's back but allow the base-material to breathe. 'They', of course, are the versatile I.C.I. Silicone Fluids and Resins. As water-repellents for masonry, textiles and leather, they're something rather special. They penetrate without forming a sealing skin, they don't affect appearance, they increase resistance to stain, they improve the handling qualities of fabrics and suède. Wherever the problem is to allow the air in while keeping the wet out—in treating building surfaces, in showerproofing clothes, in waterproofing shoes — these I.C.I. Silicone Water Repellents are finding a ready application. And talking of applications, there's probably one in your industry for silicone rubbers, resins or fluids. They're not only water-repellent — they insulate, prevent sticking, resist very high and very low temperatures and suppress foam. If you have difficulties in any of these fields, let us know about them: I.C.I. Silicones provide a beautifully simple answer to the ugliest problems.

ICI Silicones

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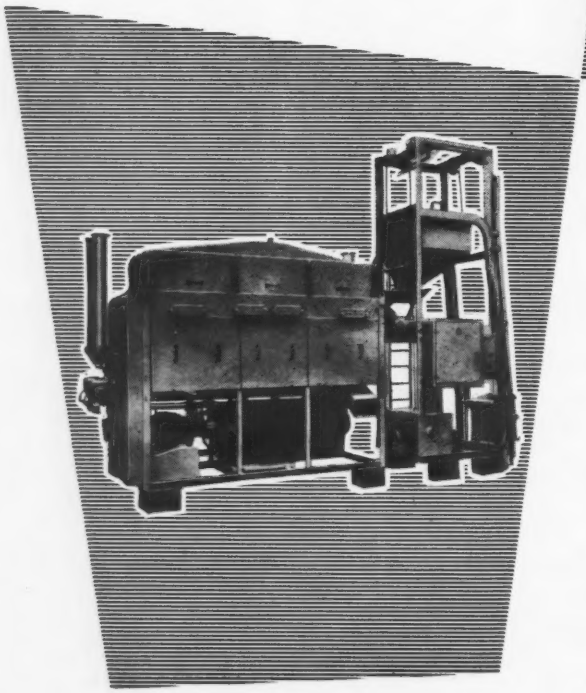
Washing Bolts and Nuts Down Under



At an Australian Factory of Guest, Keen & Nettlefolds Ltd., bolts and nuts are washed, rinsed and dried by this Dawson Rotary Drum machine at the rate of up to 10 - 15 cwt. per hour. This is only one of the many applications of this highly efficient metal parts cleaning machine which is widely used in this country and overseas for handling parts as widely different as H.E. Shells, hydraulic brake fittings, tap bodies and pipe fittings. And Rotary Drum machine is only one of the Dawson range of metal parts cleaning units which are available for handling everything from small typewriter parts to large diesel engine cylinder blocks.

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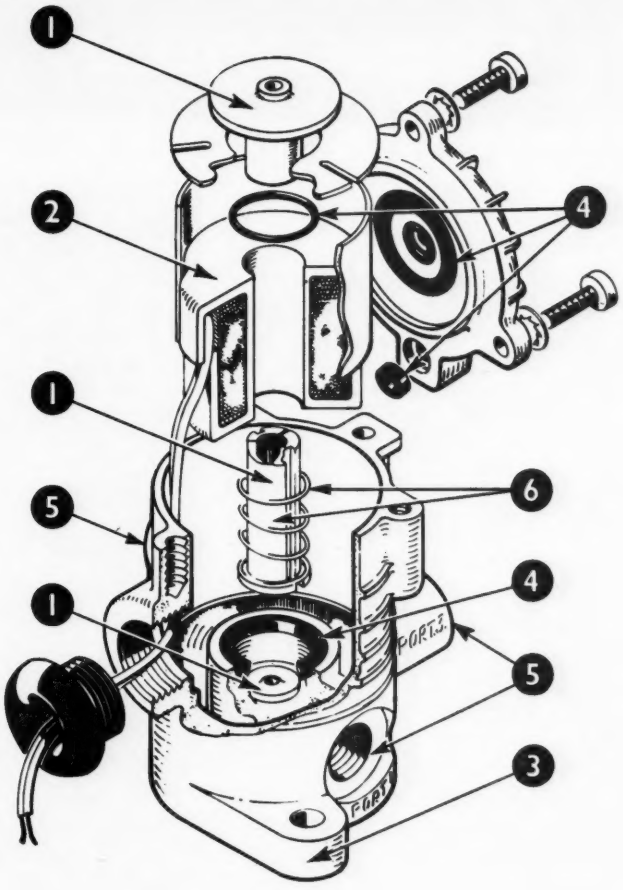
Detailed design and precision machining explain MAXAM quality and unfailing operation



Exploded for production engineers to appreciate its superior reliability, here is a pilot solenoid valve by MAXAM:-

1. ***Seats and Plunger*** — manufactured from plastic iron, heat-treated to provide maximum wear-resistance consistent with optimum electrical characteristics.
2. ***Encapsulated Coil*** — each one subjected to a 24-hour water immersion test before assembly. Available in a wide range of AC and DC voltages. Heat dissipation assisted by controlled medium passing through centre of coil.
3. ***Mounting Attachments*** — cast as an integral part of valve body.
4. ***Seals*** — of special synthetic rubber compound which resists the action of specified liquids and gases.
5. ***Operation*** — the valve can be arranged for two or three-way normally open, or normally closed operation.
6. ***Only 2 Moving Components*** — movement is confined to the plunger and spring, reducing wear (and consequently maintenance) to the minimum.

* ***Manifold Mounting*** — the valve body base can be drilled (drill-point recesses are provided) for mounting on a machined face.

* ***Compactness*** — overall height of the valve is only $3\frac{1}{16}$".

* ***Operating Pressures*** — range up to 250 p.s.i. depending on the valve arrangement and orifice size.

The design above is typical of the meticulous attention to detail and the superior care taken to ensure that MAXAM controls and air/hydraulic components shall work infallibly for as long as possible on the minimum upkeep cost. The whole assembly complies with the MAXAM emphasis on quality and reliability.

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Also alternatives :
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Sizes made to admit 45", 54" and 72" between centres

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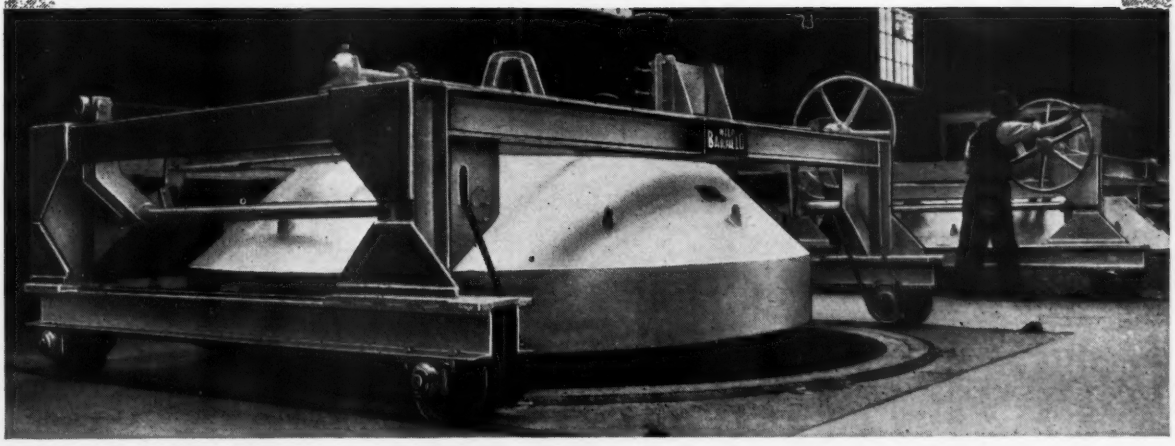

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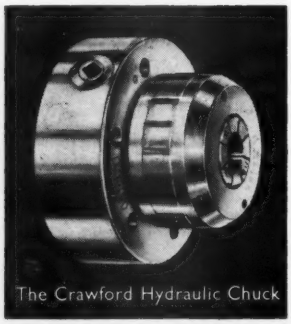
The Crawford Hydraulic Chuck

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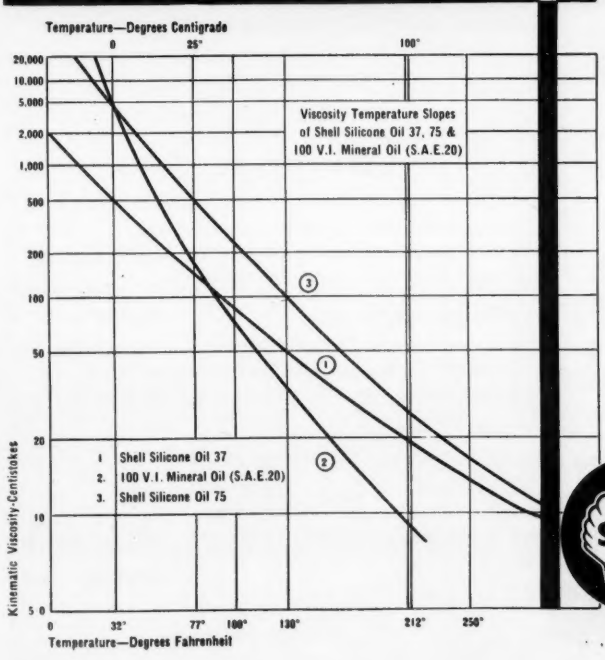
SHELL SILICONE OILS are exceptionally resistant to oxidation, possess good anti-corrosion qualities, and do not thicken, gel or form gummy materials even after prolonged heating at 250°C. At even higher temperatures they can be used for short periods. Shell Silicone Oils show a relatively small change in viscosity with temperature. Further advantages are their low volatility at elevated temperatures and low pour point.

Shell Silicone Oils therefore offer distinct advantages under normal load conditions in applications where wide variations in temperature occur. Shell Silicone Oils 37 and 75 cover most viscosity requirements, and a graphited version, Shell Silicone Oil 75G, is also available.

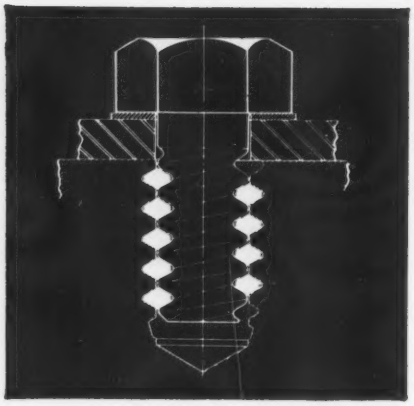
SHELL SILICONE GREASE is a lithium base grease made with Silicone Oil. It is particularly suitable for applications where comparatively long life at temperatures around 150°C to 200°C is required, and is designed for use in low- and medium-speed, plain and rolling bearings.

Shell Silicone Grease is also available containing MoS_2 for the lubrication of sliding surfaces and anti-friction bearings at temperatures above 200°C.



If you or your organisation would like to know more about Shell Silicone Lubricants, please get in touch with your local supplier of Shell Industrial Lubricants.

SHELL LEADERSHIP IN LUBRICATION



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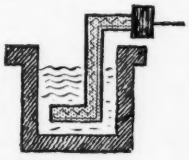
Electrical Aids in Industry *Data Sheet* **No. 5**

Resistance Heating – 2

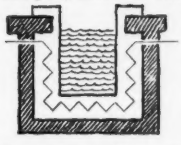
Electric resistance heating elements have been briefly described in Data Sheet No. 4, with two examples of their application in industry. This sheet lists some of the further applications which can be effectively dealt with by resistance heating.

Soft Metal Melting

Electric resistance melting is most commonly used for lead, tin, zinc, antimony, aluminium and their alloys—in processes such as tinning, type-casting, die-casting and lining bearings—at temperatures of up to around 800°C.



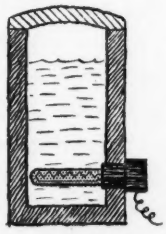
In most cases, sheathed elements are immersed directly in the metal, a more efficient method than applying heat to the outside of the containing vessel or pot. Immersion heating simplifies the application of lagging to the outside of the vessel, reducing heat losses and current consumption to a minimum. The elements are usually positioned near the inside wall of the vessel, leaving plenty of working space, but in a few cases, where the full volume of the pot is required, or where the metal to be melted is particularly corrosive, the elements are positioned outside the pot, often in contact with it.



In all cases, the precise temperature control that is so essential in soft metal processes is readily achieved by the use of electricity, and electric heating also leads to a reduction of casting rejects and metal wastage and a marked improvement in working conditions.

Liquid Heating

Electricity provides the ideal way of heating liquids such as water, oils, varnishes, plating, photographic and other solutions, and of melting and heating waxes and compounds, glues and pastes, tars and bitumen. Again, immersion heating is the method most commonly employed, but considerations of space or the nature of the liquid may sometimes necessitate the use of external heaters. Several types of devices are available to give precise and automatic temperature control, and lagging is again commonly applied to the vessel to minimise heat losses.

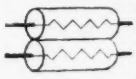


Fire hazards associated with inflammable liquids are invariably reduced by electric heating, particularly if immersion heaters can be used.

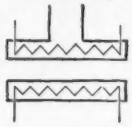
It is usually possible without difficulty to apply electric heaters, either immersion or external, to existing vessels.

Platen, Press and Roll Heating

Electricity offers the simplest and most convenient method of heating platens, dies and rolls. It gives the precise temperature-control characteristic of electric heating systems, with lower maintenance costs. Moreover, the relatively high temperatures required in some processes for maximum working speeds are reached without difficulty. Flexible electrical connections to moving parts give far less trouble than flexible pipe connections carrying hot water or steam.

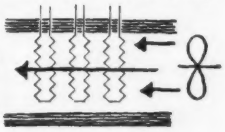


When electric heating is used, one or more presses can be operated without the necessity of keeping a boilerhouse staff at work.



Air Heating

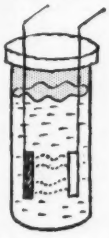
Streams of air, and of many other gases, can be heated most efficiently by electric resistance elements disposed across the duct leading to or from a fan. Heat is generated only inside the duct, just where it is required, and none is carried away through exhaust flues or pipes. Quick rise of temperature and precise temperature control are assured when electric resistance air heaters are used.



Electric Steam Boilers and Steam Raising

When steam is essential to a process, electrical steam raising can often be fully justified on economic grounds.

The means employed for bringing steam from a boilerhouse to the point of usage are often extremely wasteful, but where electricity is used the steam can be generated on the spot and losses from steam mains are eliminated. The efficiency of the electric boiler normally exceeds 96% and is practically constant at all loads, while the rapidity with which steam can be raised very largely eliminates banking losses.



Plant requiring process steam can be equipped with its own electric steam boiler, freeing the working space of steam mains ust as individual electric motor drives free the factory of masses of shafting and belt drives.

Even where boilerhouse steam is still used, it is sometimes desirable for best results to boost the steam temperatures at the point of usage, to make up for transmission heat losses or to increase the superheat, and this function can most conveniently be performed by an electric resistance heater inserted in the steam line.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available– "Resistance Heating" is an example; "Induction and Dielectric Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

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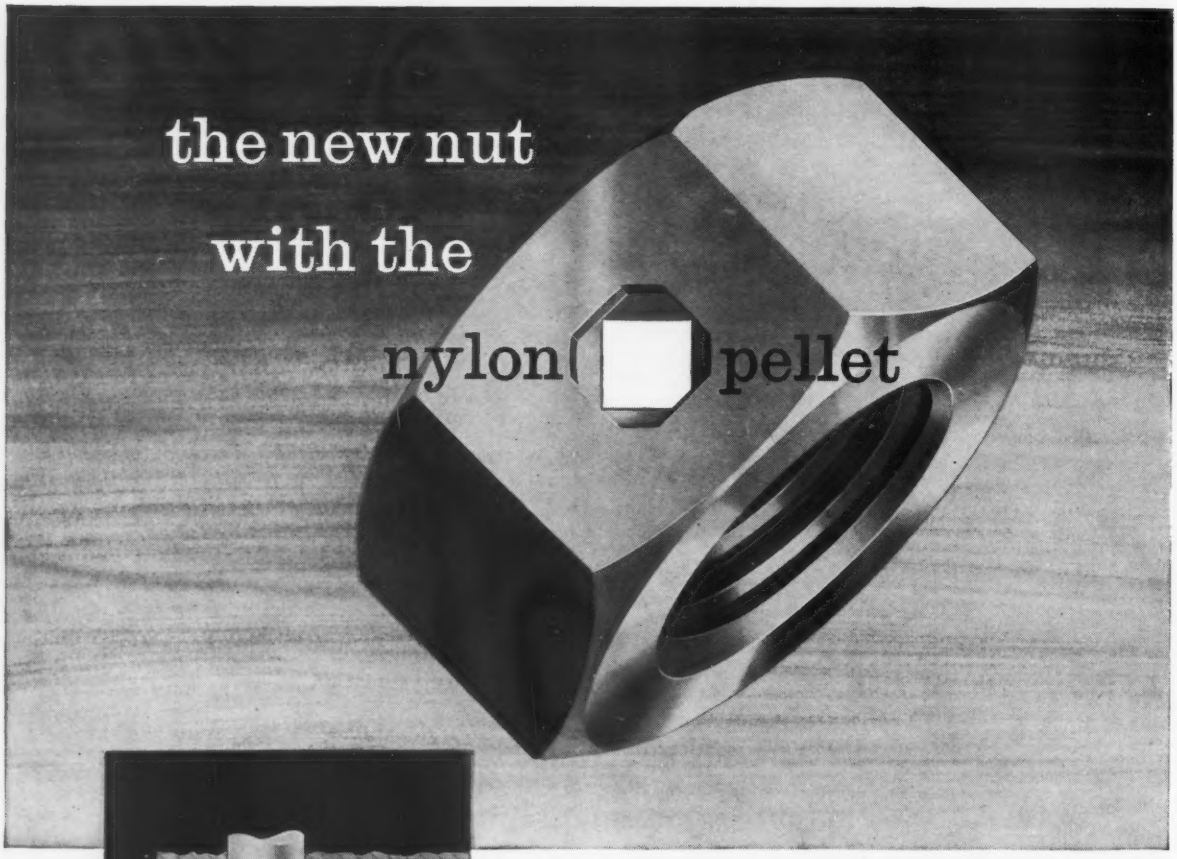
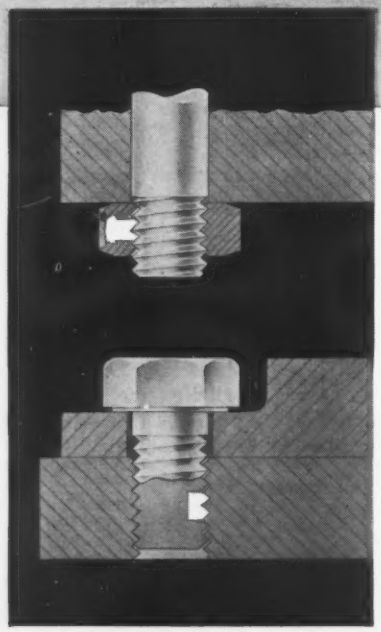
WEDGLOK





Wedglok nuts are completely self-locking. They will not work loose through vibration or reversal of stress. They need no locking devices—and the locking-action is unaffected by age or temperatures within the normal range.

How is it done?

In a Wedglok nut the locking element consists of a tough, resilient nylon pellet. This is inserted in the body of the nut and projects slightly above the crest of the thread. When the nut is turned the pellet sets up a wedging action, gripping the threads tightly. This counter-thrust creates metal to metal engagement of mating threads. The Wedglok principle can be applied to screws as well.

If it's a matter of how to fasten one thing to another . . . get in touch with GKN

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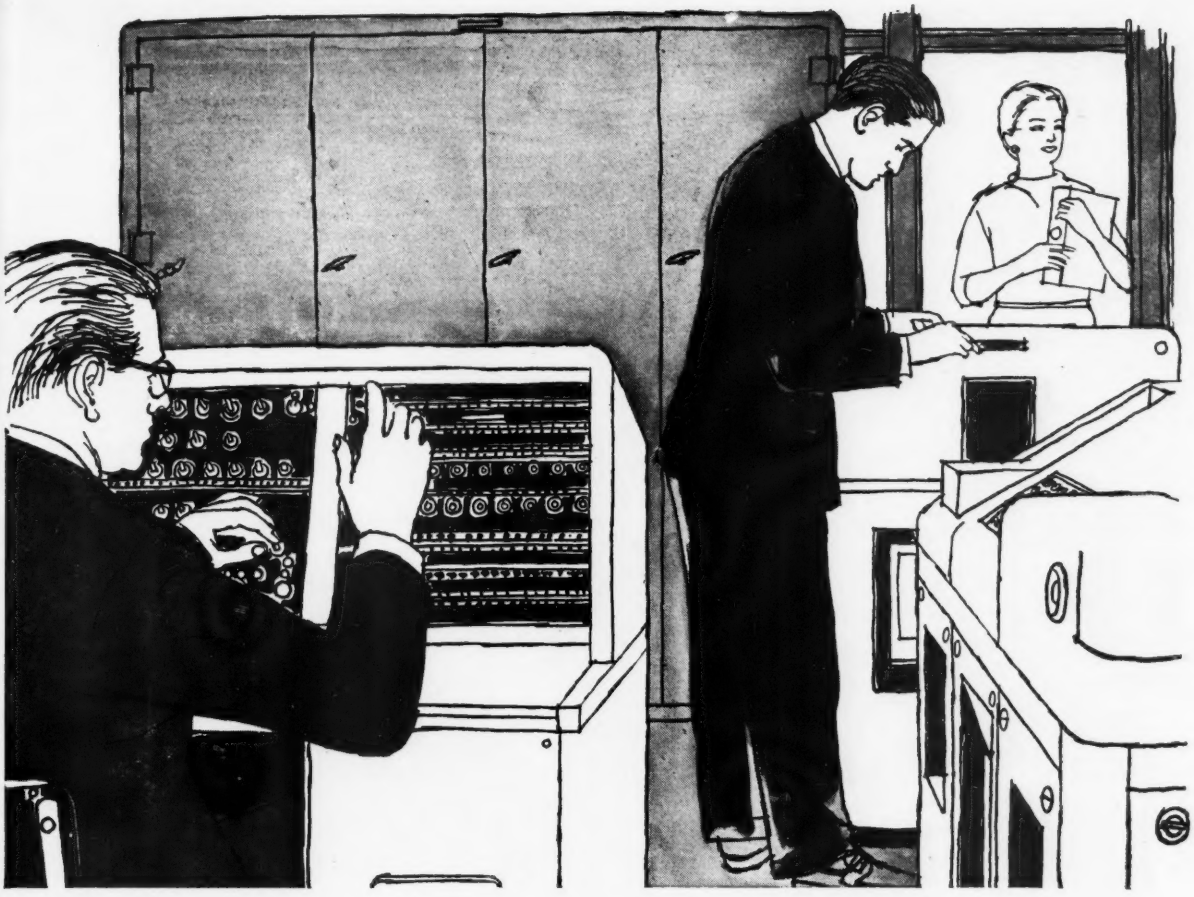

Searching for the right answer

Data processing continues to play an increasingly important role in the conduct of modern business. Punched card equipment, electronic calculators and computers provide more business information in less time than any other form of office machinery. Users of these methods have always known most about their business soonest.

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Determining the optimum method of employing data processing equipment is a highly skilled task. I·C·T staff are experienced in these matters; their knowledge and experience have proved valuable to enterprises of widely divergent character and size, from firms employing under 20 people to corporations of international repute, local authorities and nationalised industries. They can help you.

If you think your research, production, marketing or financial affairs are capable of improvement there are well established reasons for believing that the combination of I·C·T staff, equipment and training will provide you with the right answer. We suggest you get in touch with us.

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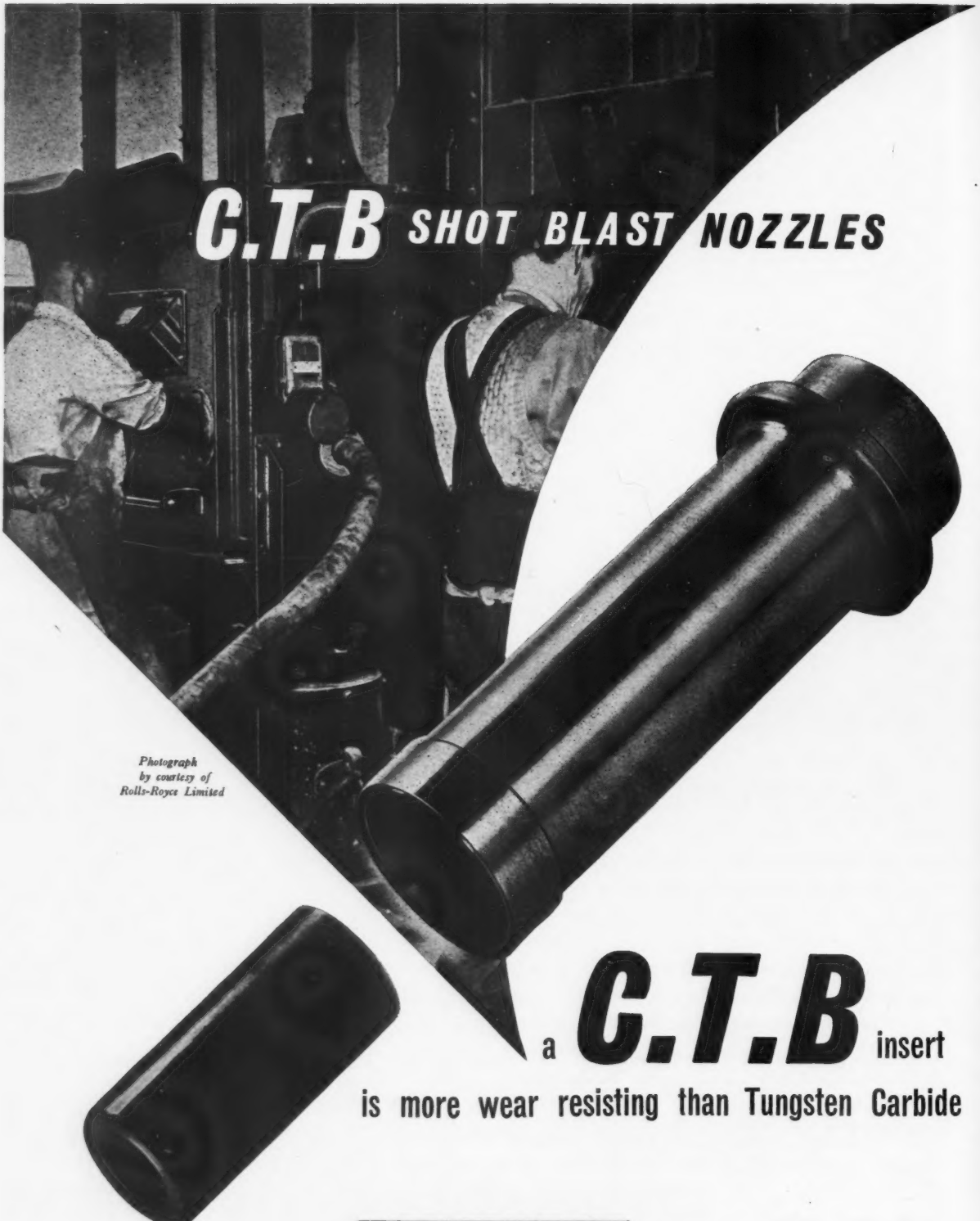

C.T.B SHOT BLAST NOZZLES

Photograph by courtesy of Rolls-Royce Limited

a **C.T.B** insert

is more wear resisting than Tungsten Carbide

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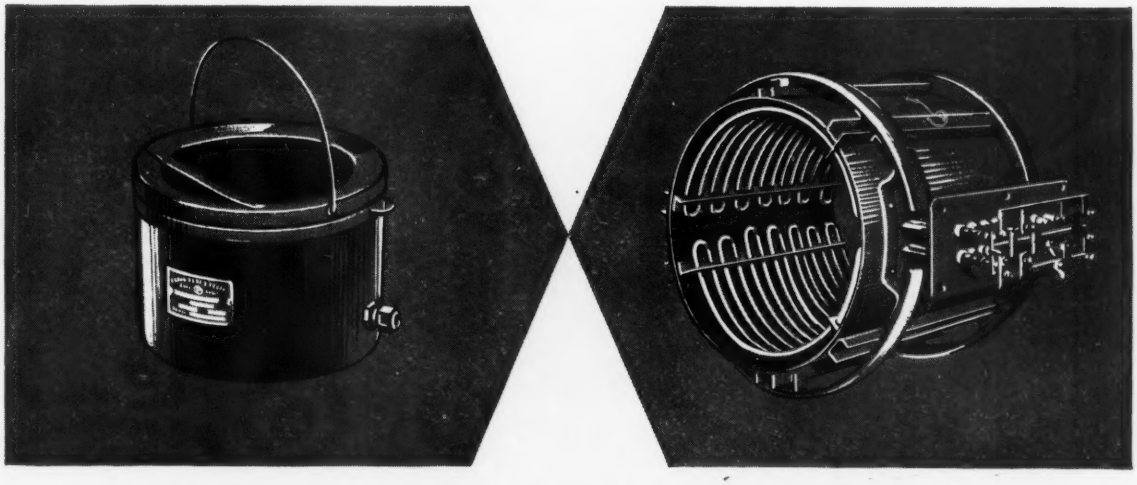

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* High application efficiency—virtually 100 per cent. with immersion heaters
* No trouble with burners or furnace linings
* Accurate. Readily adapted to automatic temperature control, making skilled supervision unnecessary
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Write for further details. Leaflet G14031, showing the wide range of heaters and their applications, will be sent on request.

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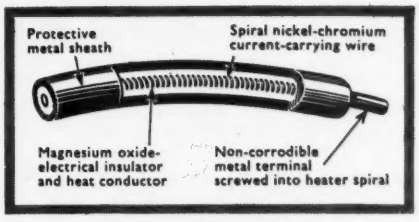
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Spiral nickel-chromium current-carrying wire
Magnesium oxide-electrical insulator and heat conductor
Non-corrodible metal terminal screwed into heater spiral

Section of 'Pyrobar' element

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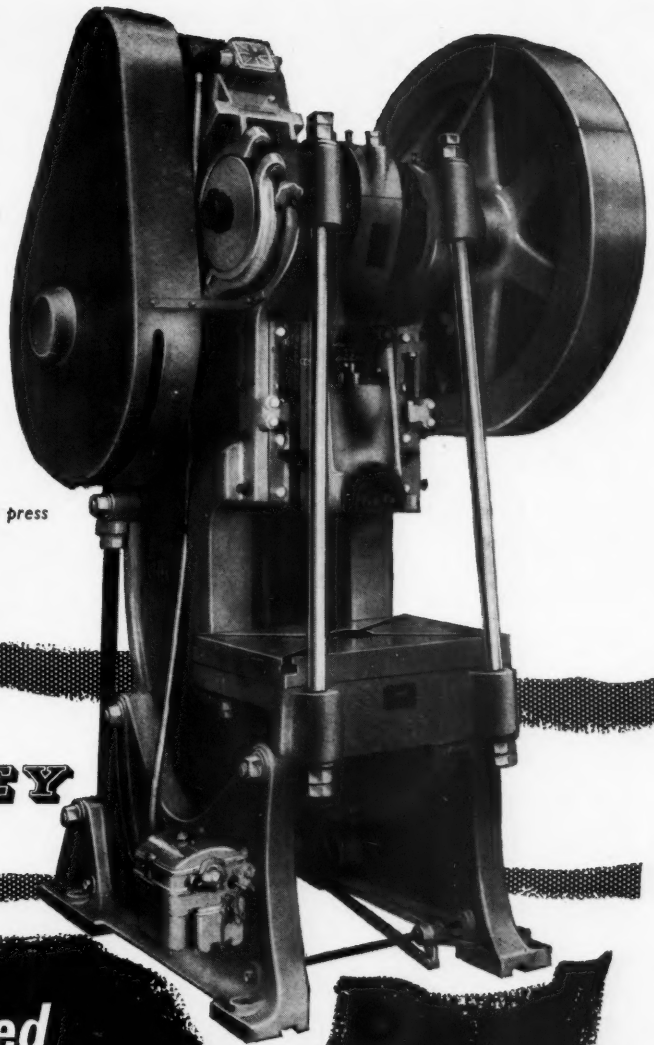

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All castings are made by the " Meehanite " process in our own well-equipped foundries. The Butterley foundries are available for the production of high-grade " Meehanite " castings to customers' requirements.
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SM 24

Rapid, high-quality photoprinting

and no ventilating system required

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- Exposure, development and print delivery synchronized for simplicity of operation.
- All controls conveniently located for rapid, effortless adjustment.
- Pneumatic-assisted handling of originals and sensitised material to obviate fatigue.
- Complete design co-ordinated for exceptionally high potential output.
- Excellent mechanical layout giving silent, vibrationless running.
- Comprehensive maintenance service available at nominal cost.

Capacity: rolls and cut sheets up to 42 in. wide.
Printing speed: from 2 ft. to 30 ft. per minute.
Lamp: H.P.M.V. quartz, 3,000 watt.
Dimensions: height, 58 in., width, 72 in., depth (tray extended) 80 in. Weight : approx. 1,400 lb.

Subject to certain conditions, the majority of AZOFLEX photoprinting machines can be hired as an alternative to outright purchase.

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PHOTOPRINTING MACHINES & MATERIALS

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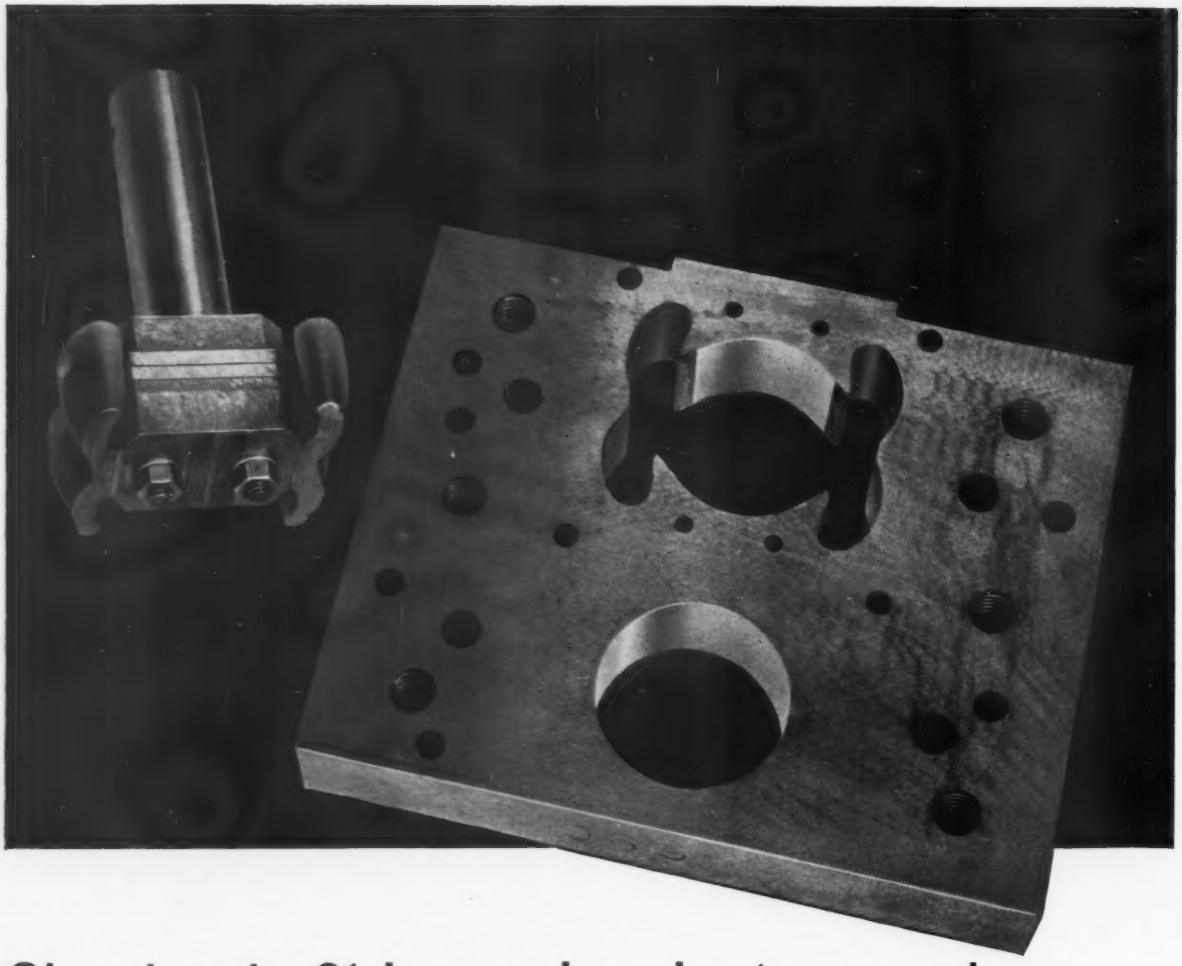

Shaping in 3½ hours by electro erosion

This die for the field laminations of a small electric motor was cut in a previously hardened 1″ die plate in 3½ hours. The method—electro erosion by GKN Spark Machine.

Now consider. How long would it take you to shape the same die by normal methods? GKN Electro Erosion simplifies the cutting of complex shapes; makes easy the working of hardened steels and tungsten carbide.

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GKN spark machine

DESIGNED BY THE GKN RESEARCH LABORATORY

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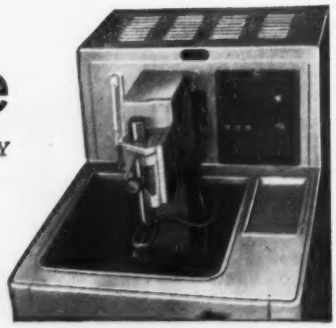

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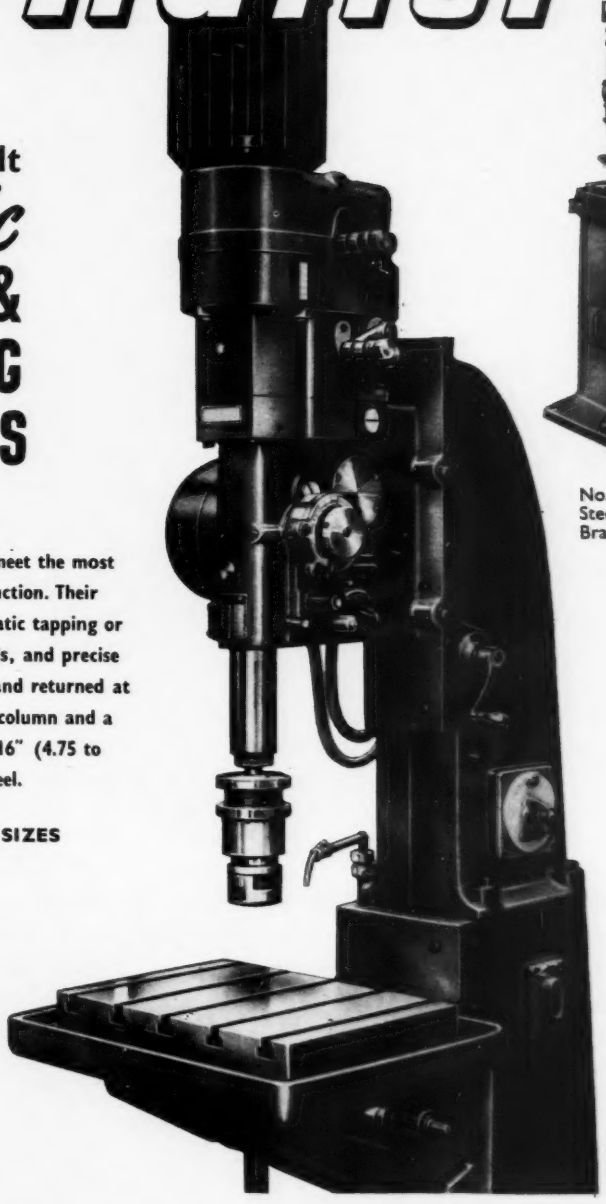
Steel $\frac{5}{16}$ in.
Brass $\frac{5}{16}$ in.



No. 5:
Steel $1\frac{3}{16}$ in.
Brass $1\frac{1}{2}$ in.

Fast and easy to operate, these machines meet the most stringent demands of modern mass production. Their outstanding features include entirely automatic tapping or threading operations, a wide range of speeds, and precise limitation of feed depths; the spindle is fed and returned at the exact pitch. The range includes bench, column and a radial type. Capacities from 3/16" to 1.3/16" (4.75 to 30.16 mm) thread diameter, in steel.

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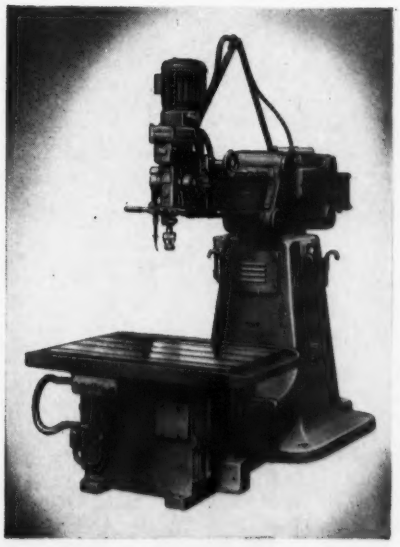

No. 3 Radial: Steel $\frac{1}{2}$ in. Brass $\frac{1}{2}$ in.

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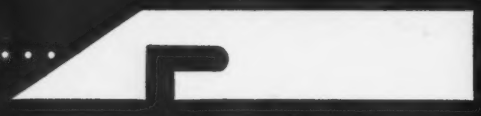

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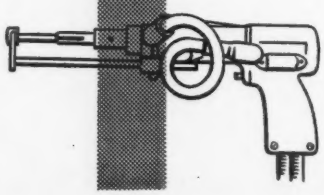

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The three bores (two at 0.625 in. dia. and one at 0.6875 in. dia.) are repeated by two spindles at the opposite end and in addition to close limits on diameter and relative position, this multiple operation fulfils exacting demands in the accurate alignment of the opposing bores. The six holes are bored using solid tungsten carbide shank boring bars in a floor-to-floor time of 2.85 minutes.

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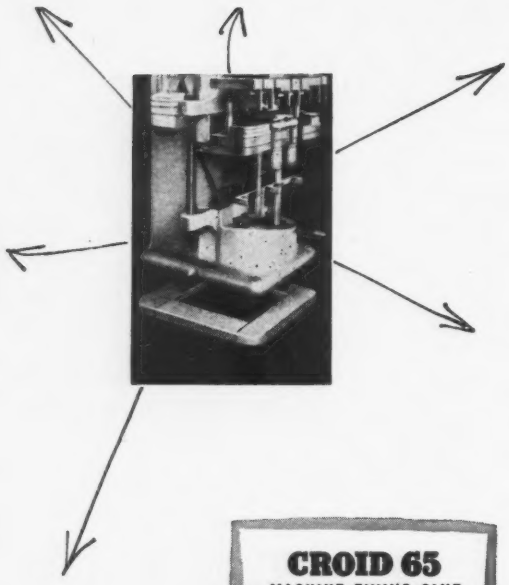

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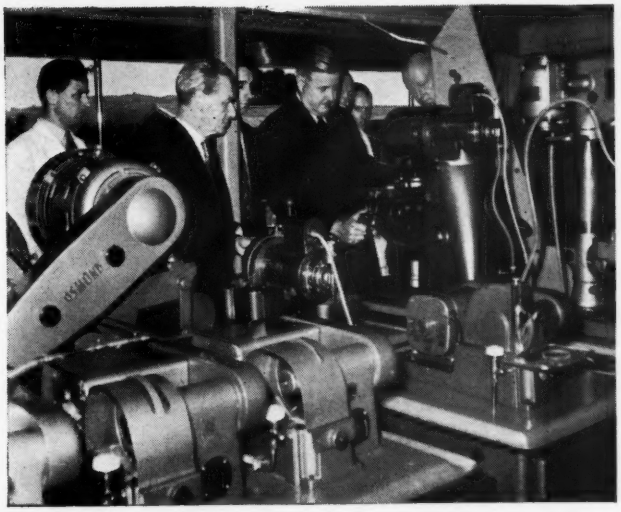

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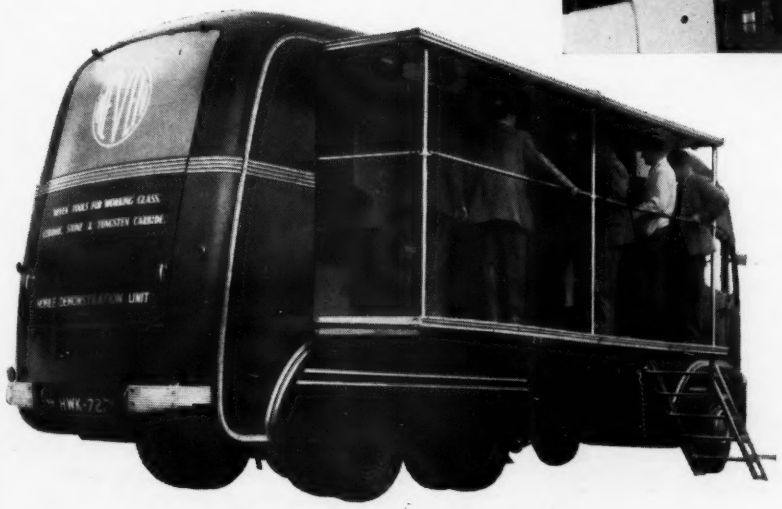

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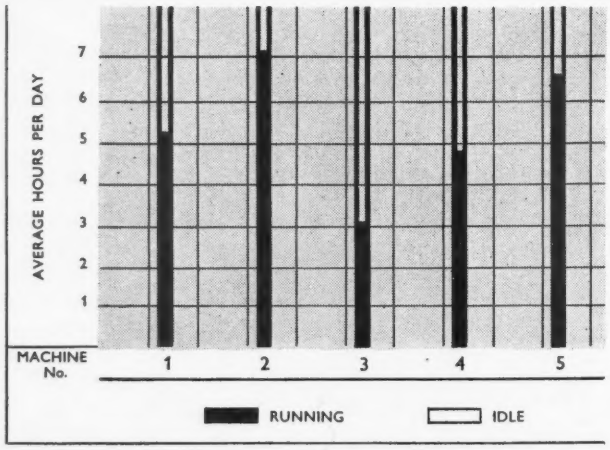
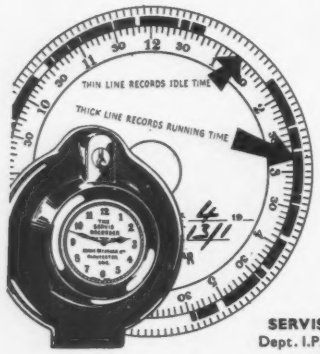
Please write for details of the Servis Recorder system.





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with the
SERVIS RECORDER SYSTEM

Machining on single spindle automatic

Do you still have trouble with tolerances?

You've checked the tool angles, the setting-up, the rate of feed and spindle speeds, but have you checked the cutting fluid? This can have a great bearing on the accuracy of any machining operation. Put a FLETCHER MILLER cutting fluid in the sump and you will notice the difference. Both tools and workpiece are thoroughly cooled, close tolerances are maintained, chip welding is eliminated—and life of the tool bit is extended. Interested? Write for a copy of Publication SP.173 "Cutting Fluids" which describes the whole range of FLETCHER MILLER cutting fluids.

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- Wide range of spindle speeds and feeds.
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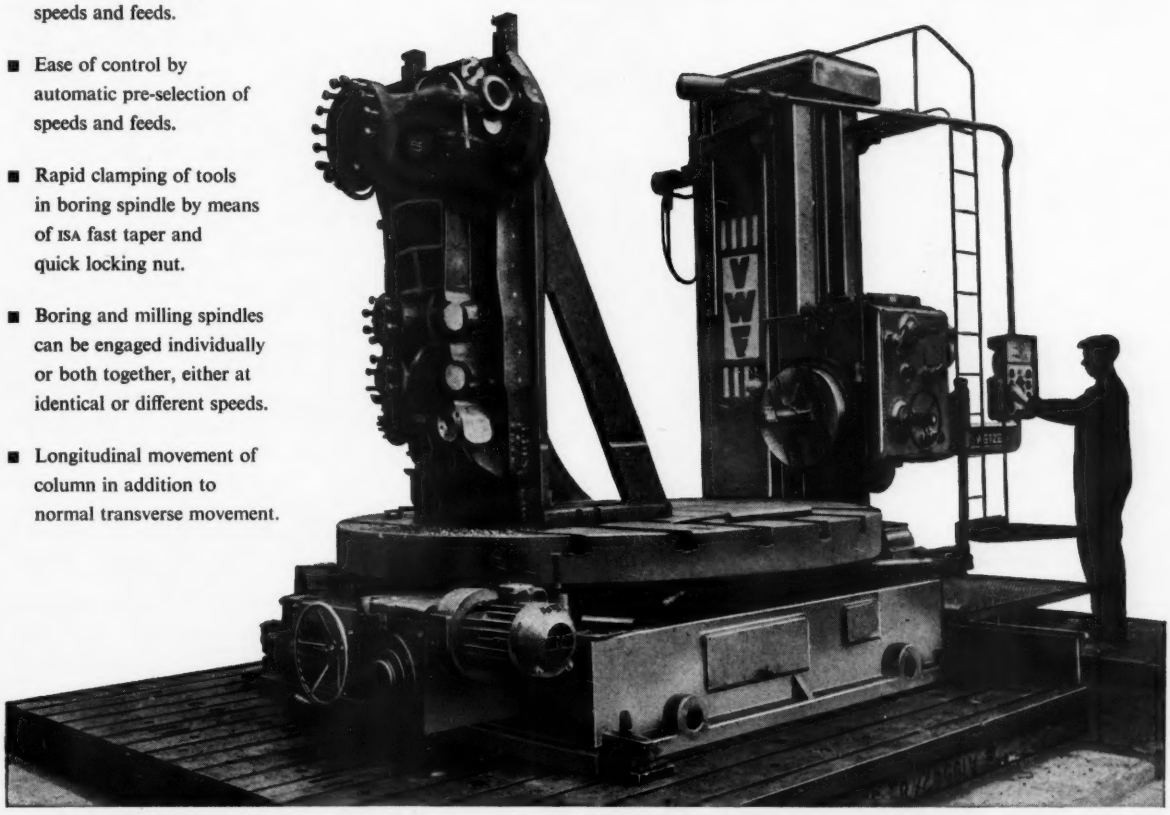

Brief description MODEL BFKn (Floor plate type)

	100/180	125/200	180/280
Boring Spindle diameter	3.9″	4.9″	7.1″
Milling Spindle diameter	7.1″	7.9″	11.0″
Distance Floor Plate to spindle centre	41″/96″	45″/116″	43.3″/157.5″
Transverse column travel	108″	138″	167″
Longitudinal column travel	15.8″	19.7″	24.8″
Depth bored in one pass/second pass	35″/14″	44″/18″	49″/25″
Maximum boring diameter	35″	44″	55.1″
Maximum milling cutter diameter	20″	25″	31.5″
Maximum facing diameter	44″	51″	59″
Number of spindle speeds	23	33	24
Range of boring spindle speeds	9–1400	5.6–1000	4–800 r.p.m.
Range of milling spindle speeds	9–315	5.6–280	4–125 r.p.m.
Number of fine speeds	36	36	*
Range, per rev. of boring spindle	.0008″–47″	.0008″–47″	*
Number of coarse feeds	18	18	*
Range in inches/min.	1.02″–49″	1.02″–49″	*
Main motor capacity	20 H.P.	27 H.P.	55 H.P.
Weight without steady, and floor plate	16 TONS	25 TONS	51 TONS

★ **Infinitely variable. Fuller details on request.**

The photograph above is reproduced by courtesy of Messrs. C. A. Parsons & Co. Ltd., and shows the BFKn 125 installed in their Heavy Machine Shop.

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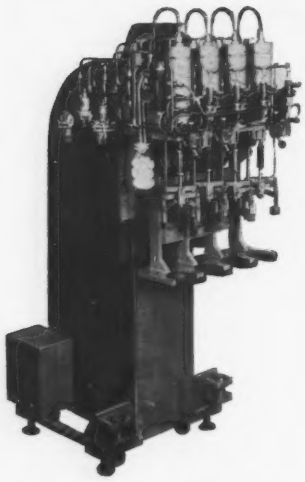

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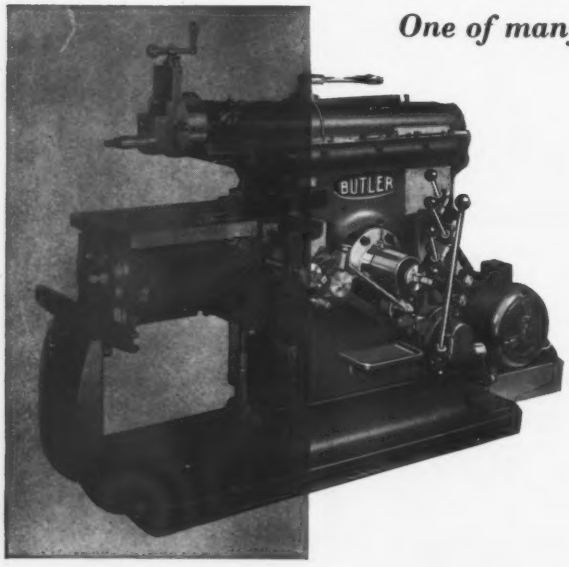
One of many different types of machines



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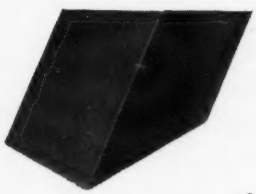

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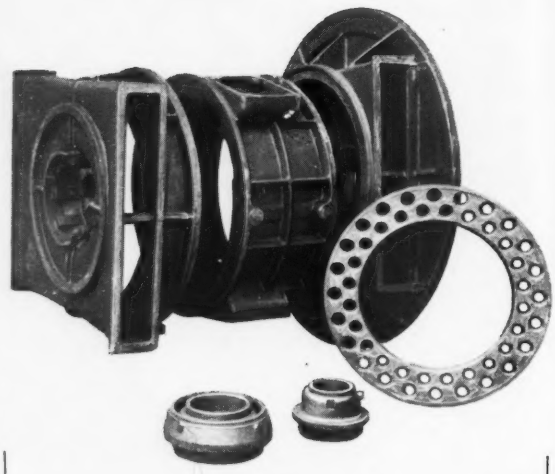

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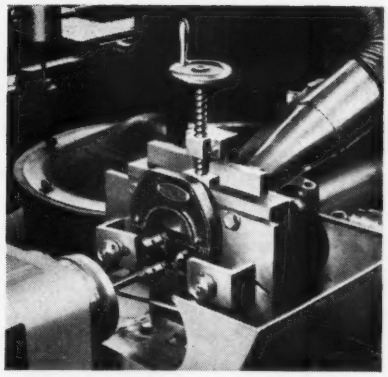

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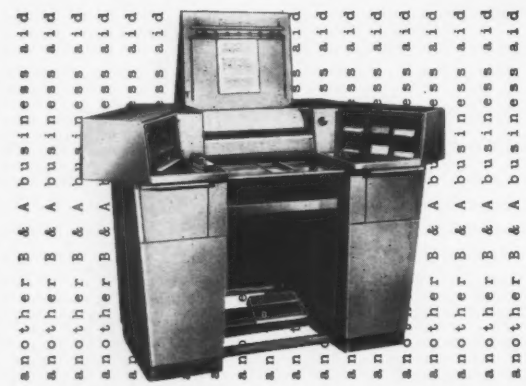

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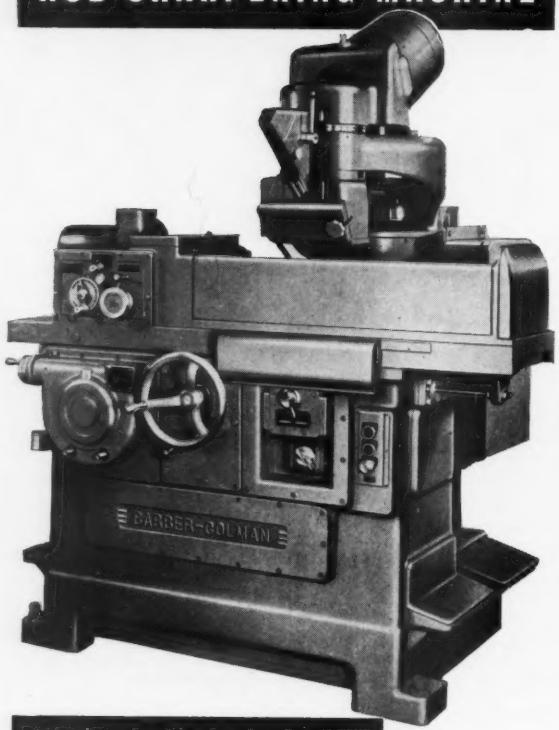

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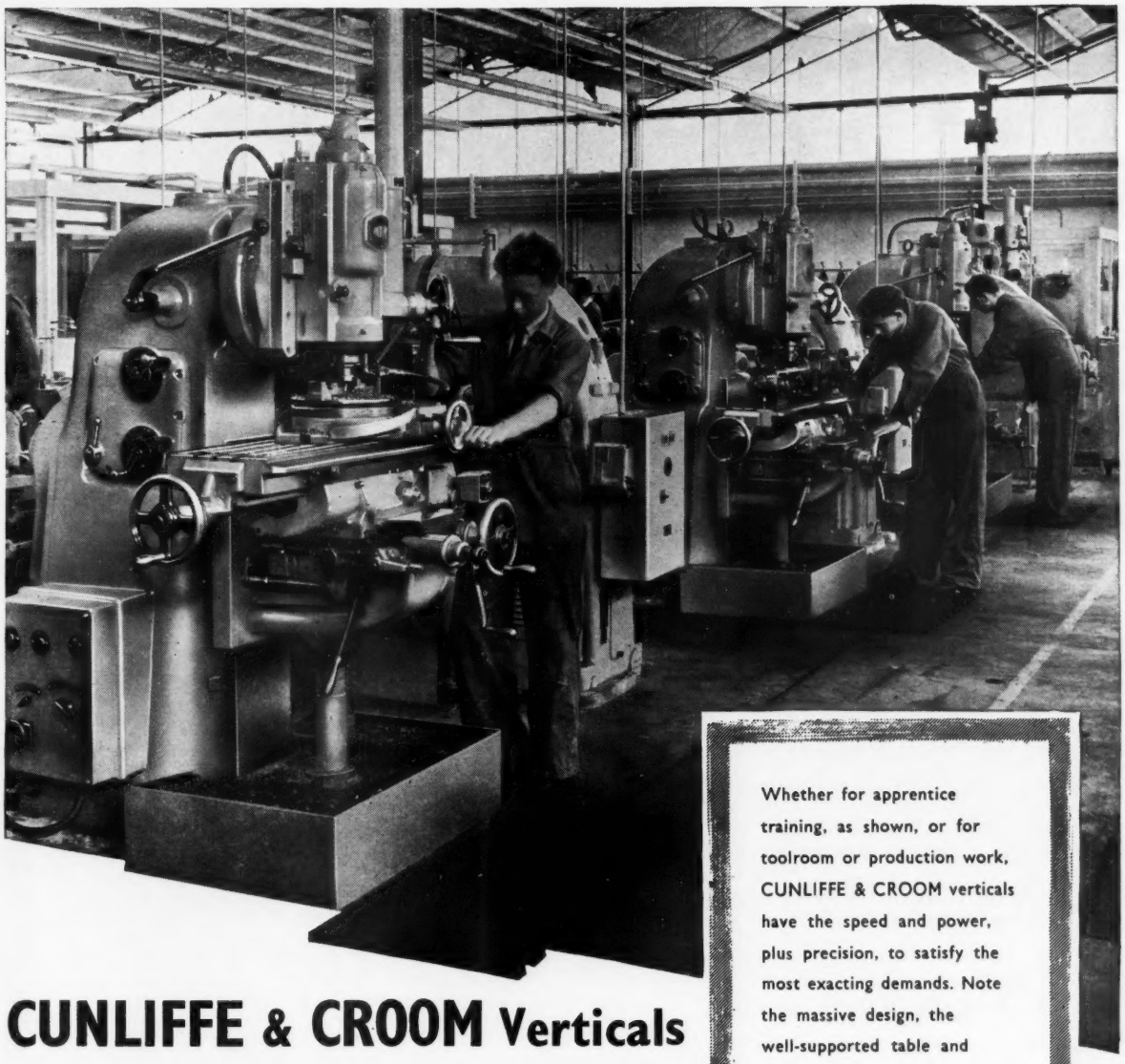

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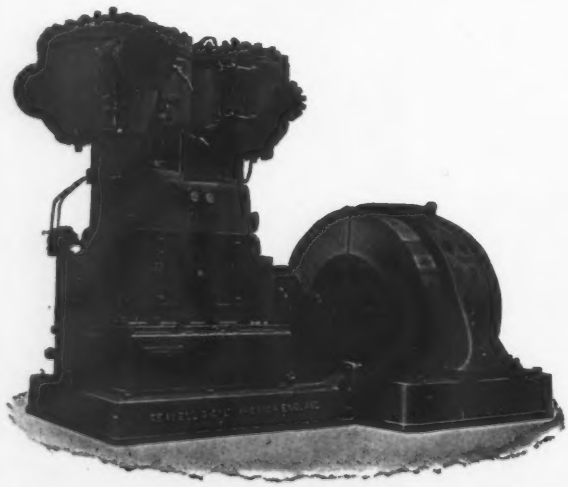

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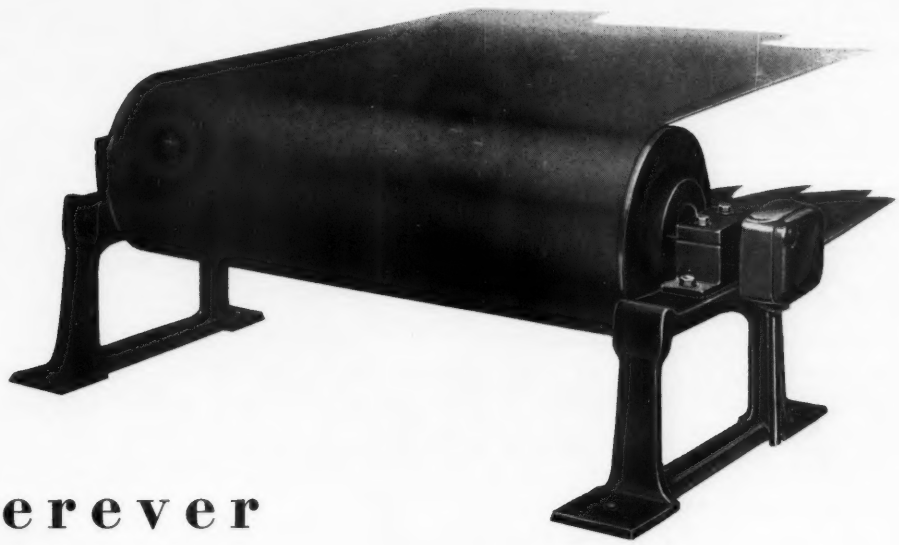

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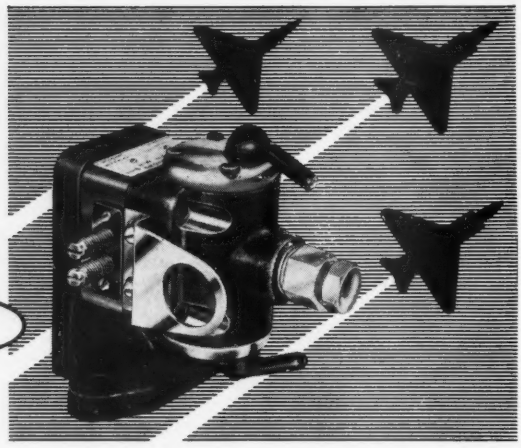

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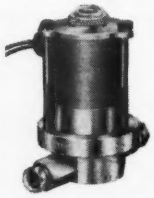

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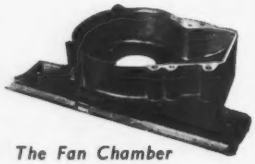

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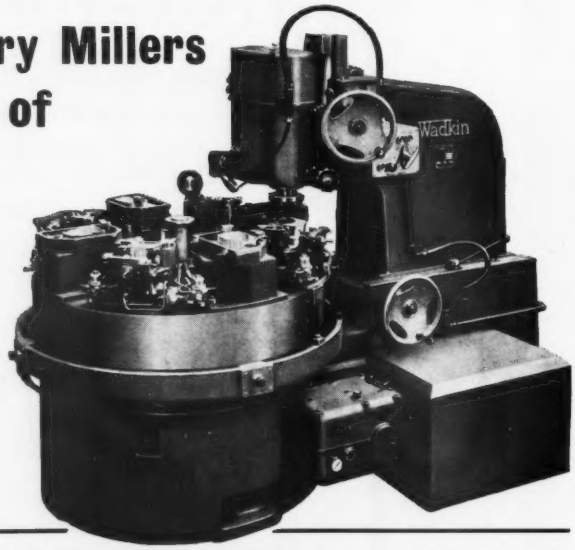

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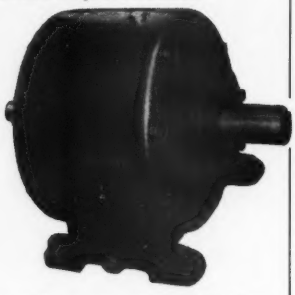

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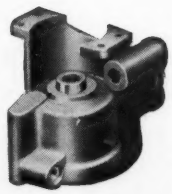

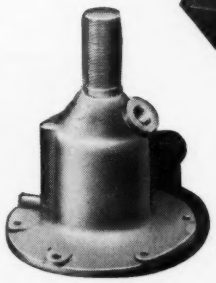

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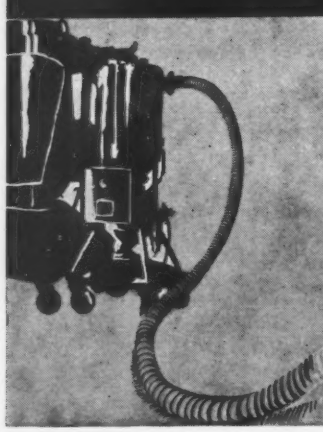

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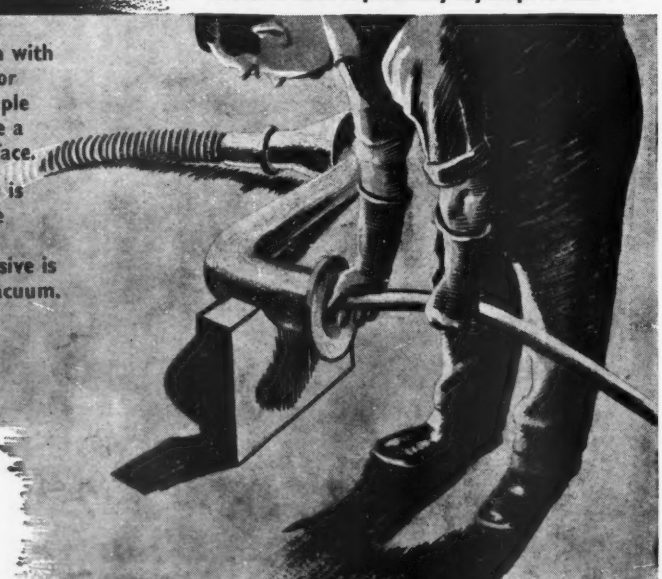

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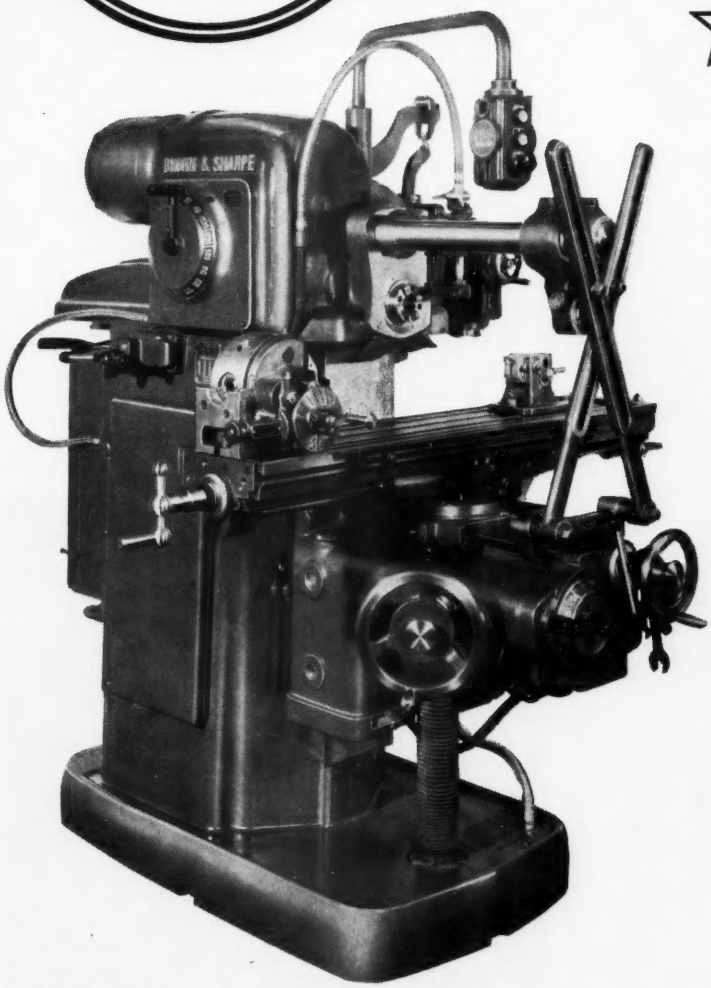

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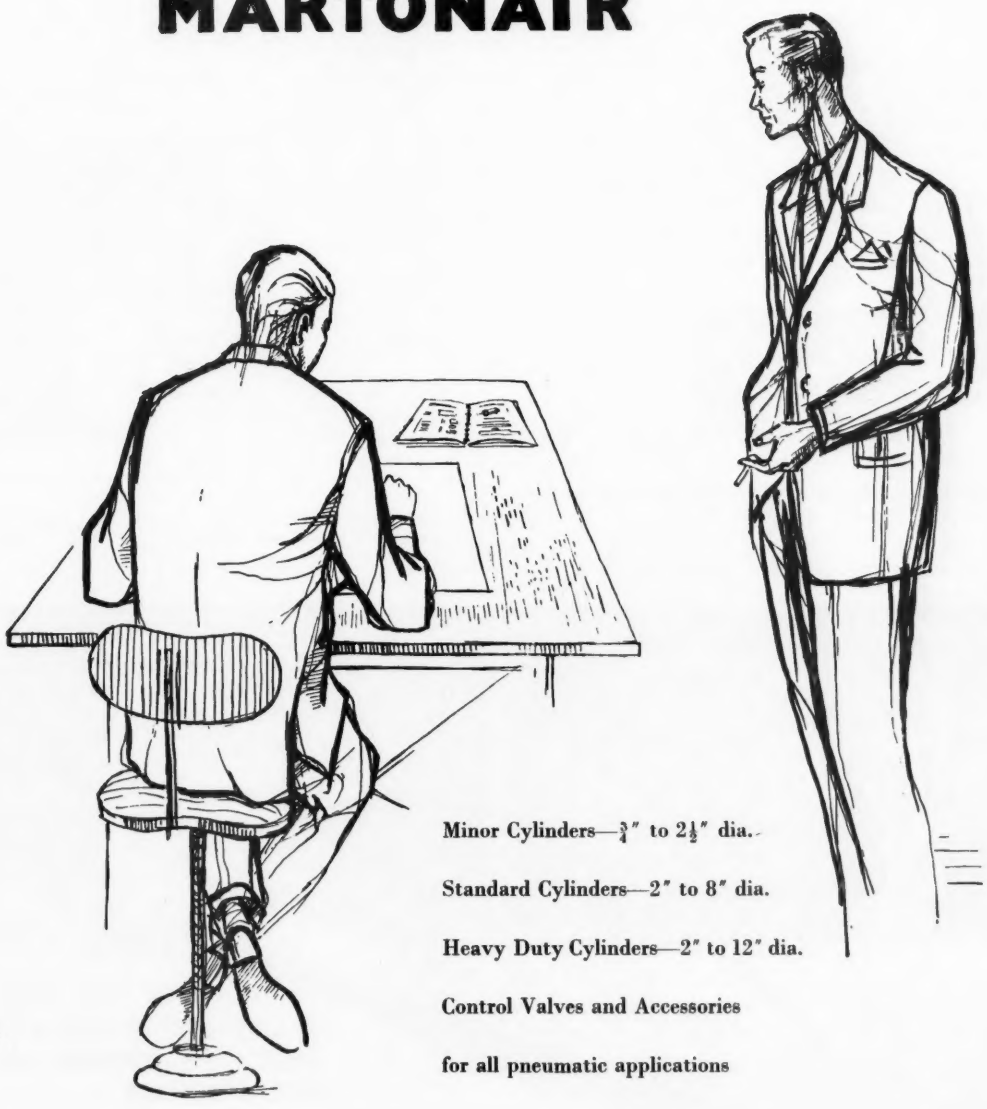

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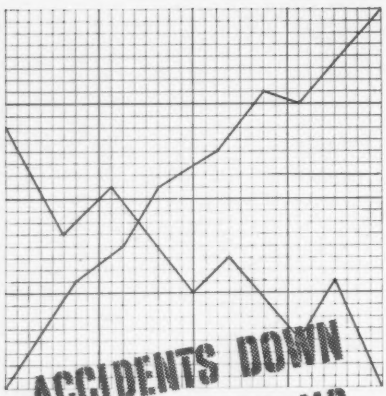

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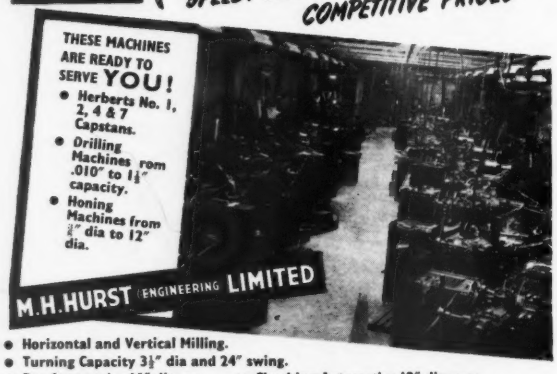
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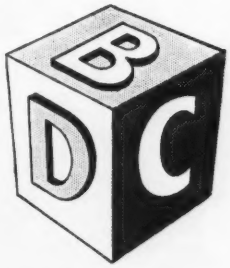

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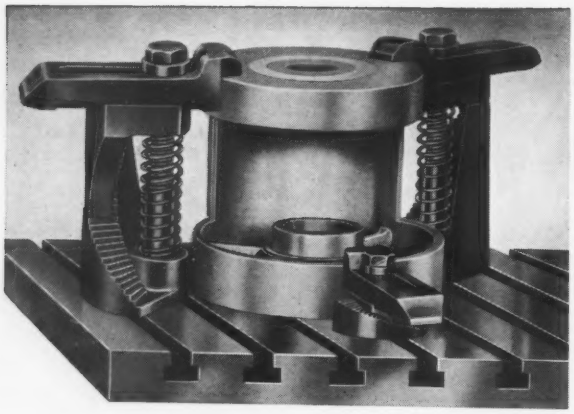

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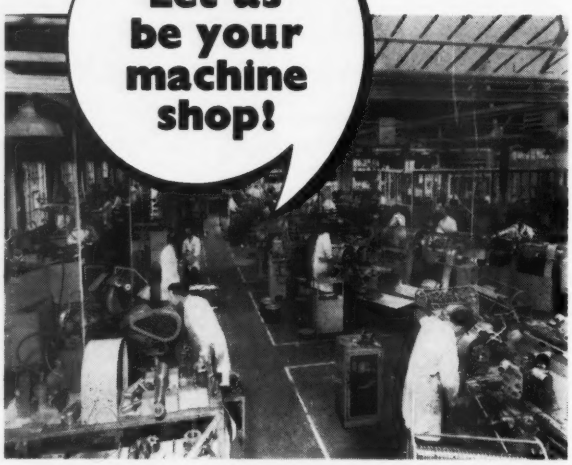

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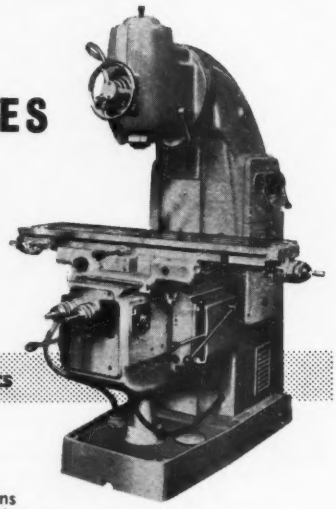
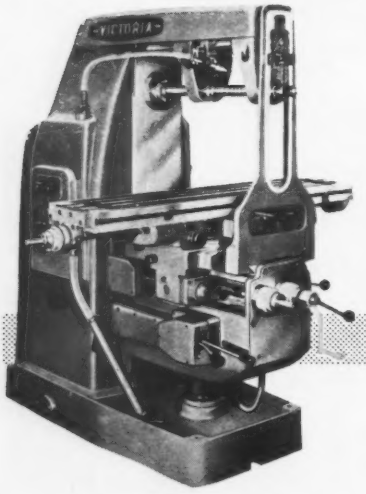


£1610 including 3 phase electrics



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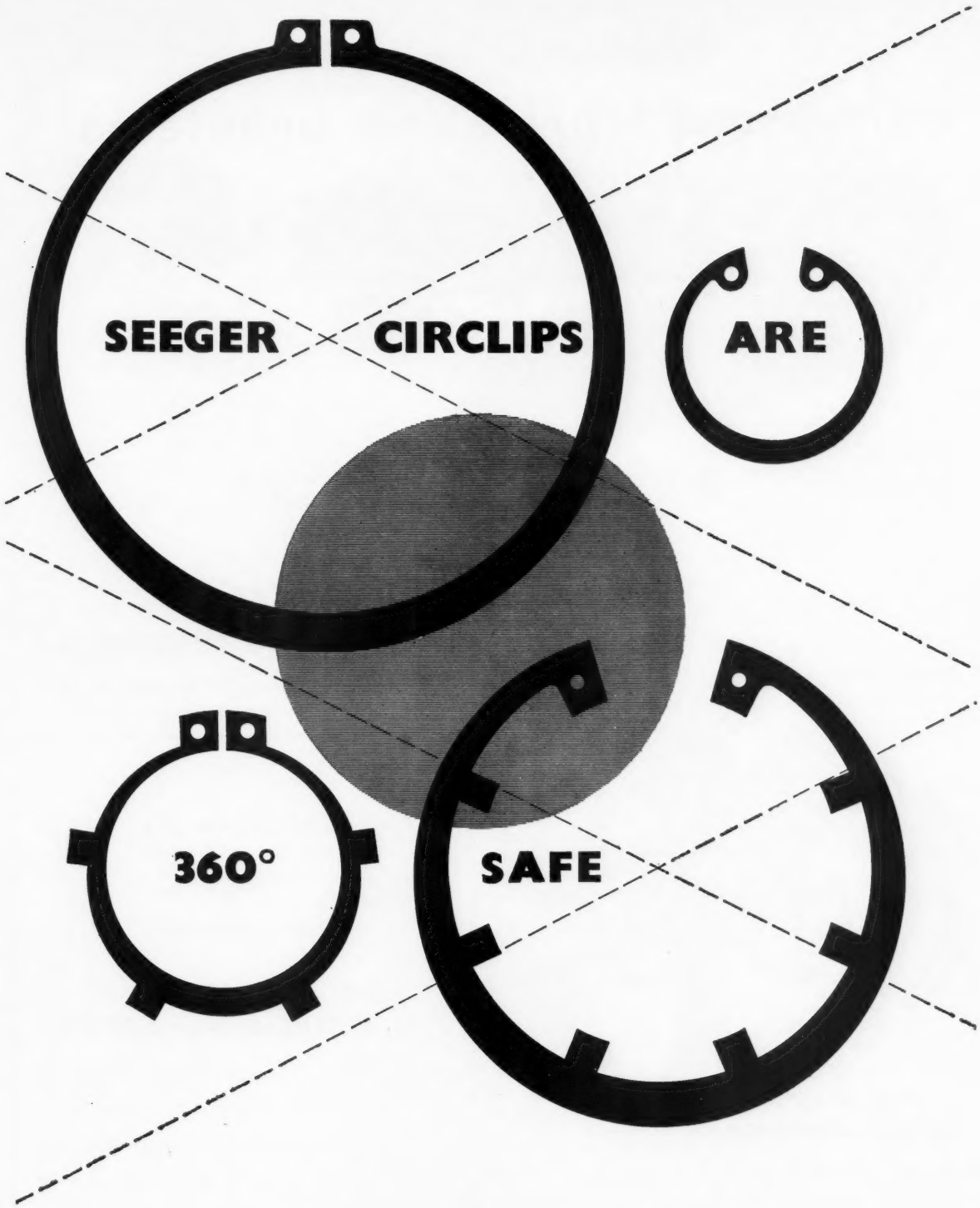

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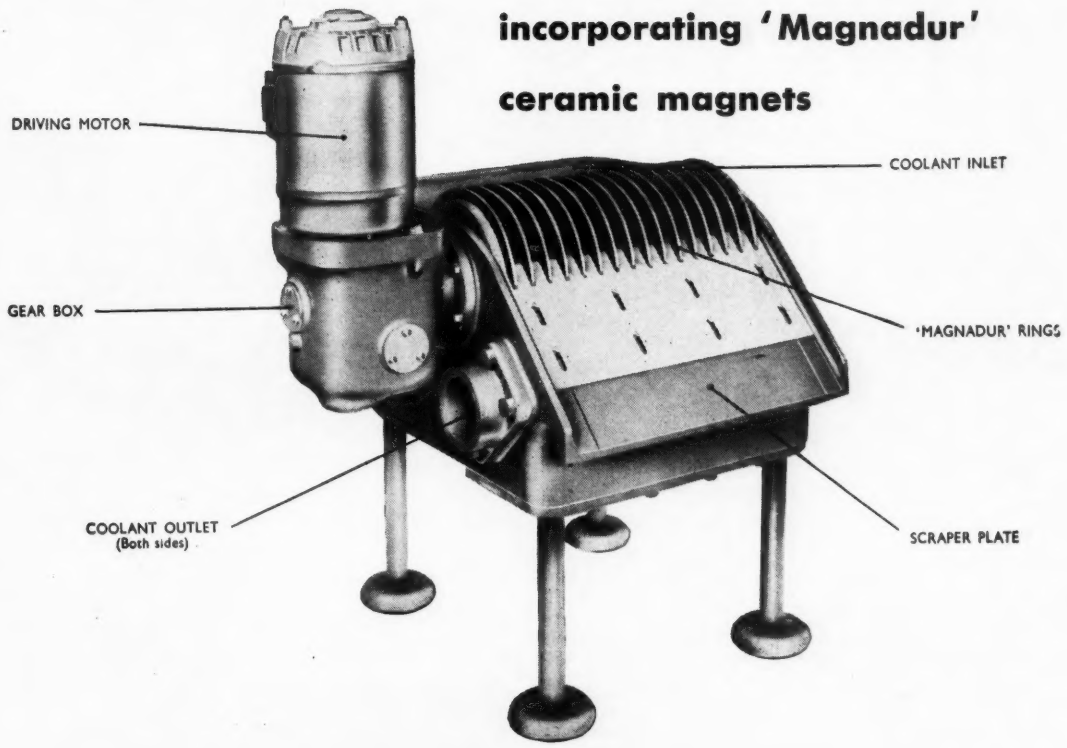

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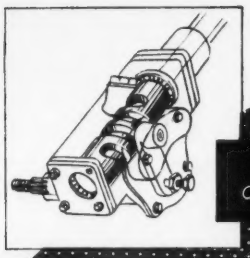

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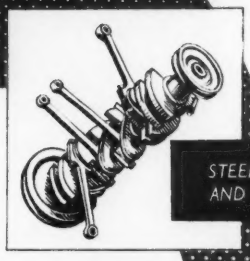

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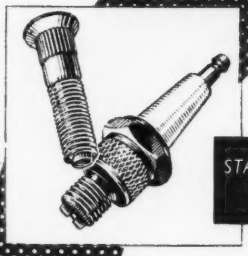

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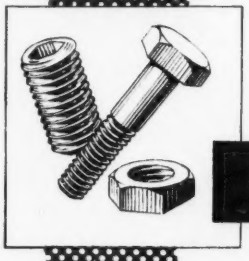

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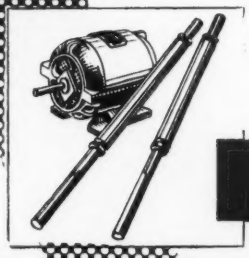

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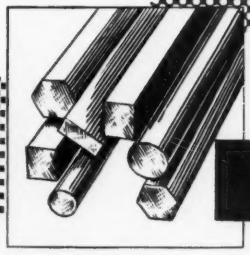

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